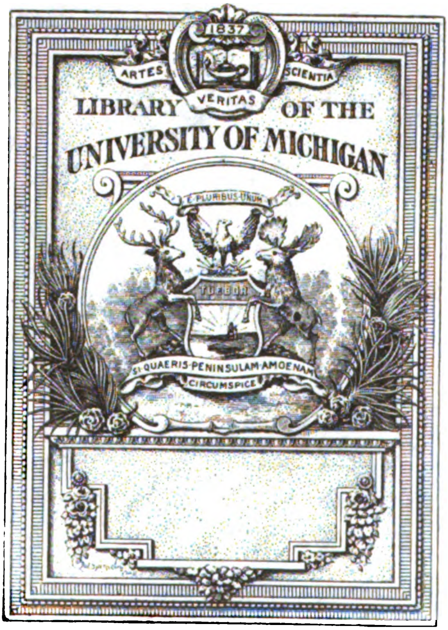
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THE

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NEW SERIES.

DECADE V. VOL. X.

JANUARY—DECEMBER, 1913.

THE

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HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.R.M.S.

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FOLDING TABLES.

LIST OF ILLUSTRATIONS IN THE TEXT.

PROFESSOR E. SUESS.

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THE
GEOLOGICAL MAGAZINE
NEW SERIES. DECADE V. VOL. X.

No. I.—JANUARY, 1913.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

Dr. Eduard Suess,

Late Professor of Geology (1857–1908) in the University of Vienna; For. Memb. Roy. Soc. 1894; For. Corr. Geol. Soc. 1863; For. Memb. Geol. Soc. 1877; Wollaston Medallist, 1896; Copley Medallist, 1903.

(WITH A PORTRAIT, PLATE I.)

TO write an adequate notice of Professor Eduard Suess' work would be to review the progress of Geology during nearly half a century, for in all that time he was actively engaged in helping to explain the great problems connected with the formation of the features of the Earth's surface, and to trace accurately the principles upon which these have been brought about.

Born in London August 20, 1831, Eduard Suess went with his parents to Prague in 1834, his father being engaged as a merchant in the City of London in wool-importing from Bohemia, a business which had declined owing to the abundant arrival of wool from Australia.

Suess' first publication appeared in 1850, entitled a *Sketch of the Geology of Carlsbad and its Mineral Waters.*

In 1851 he was appointed an Assistant in the Imperial Museum, Vienna, and in 1857 to be a professor in the University of Vienna. In 1862 Suess resigned his museum work and devoted all his leisure not occupied by his lectures in the University to palæogeographical researches, which culminated in his great work *Die Antlitz der Erde,* "The Face of the Earth" (1883–5 and following years), wherein he endeavoured to show the main factors and methods which have ruled in geographical evolution. After a period of more than twenty years from its appearance in Vienna, an English translation of the first volume by Miss Hertha Sollas, edited by Professor Sollas, was issued by the Clarendon Press, Oxford, in 1904; whilst the fourth volume in its English dress was published in 1909, bringing the total number of pages up to 2,233.

"The first translation of Suess' great work, *Antlitz der Erde,* was into French (1897–1911), an edition which, thanks to the singular erudition of its editor, Mons. E. de Margerie, has been so enriched with footnotes as to become an invaluable work of reference for published papers in every department of the wide range of subjects of which it treats" (Geikie).

In a limited notice of Professor Suess' life-work, such as the present, it would be quite impossible to give an adequate idea of the vast field of cosmical phenomena dealt with by him in his book. The dominant feature is the careful study of the earth-movements and foldings to which various districts have from time to time been subjected, some areas like Laurentia showing little or no disturbance since Cambrian times, the strata of that epoch lying horizontal, whereas other regions have been affected by more or less complex systems of foldings at successive epochs, the movements being influenced by buttresses of older rocks that have led to deflection and overthrusting.

But we must not overlook the various services rendered to science by Professor Suess during his long and brilliant career. By his lectures in the University of Vienna he exercised a powerful influence on the work of the distinguished school of geologists whom he taught —including such men as Neumayr, Mojsisovics, Fuchs, Waagen, Penck, and many others, which shows him to have been a great master of our science.

Since 1851 a steady stream of memoirs issued by him has proved him to be a great worker in geology, while the intellectual stimulus of his writings on foreign geologists shows him to be a great thinker.

Suess was never a specialist. He began work on Graptolites; he next laid the foundations of the modern classification of the Brachiopoda and Ammonites. Alpine problems roused his interest in dynamical and structural geology, and led to studies of the Austrian and Italian earthquakes, and to his suggestion of the connexion between these and the great circle of European Tertiary volcanoes and the elevation of the Alps. Work on the complex Tertiaries of the Vienna Basin and a study of the Mediterranean littoral geology led to his researches in Faunistic Palæontology, and so prepared the way for his pupil Neumayr. As a practical application of his geological studies in the Alps we may record that he greatly improved the water-supply of Vienna by bringing it from the Alps by an aqueduct 110 kilometres long.

For thirty years he was a Member of the Austrian Parliament, where he did good service for science. In 1863 Professor Suess visited London, for which city (as his birthplace) he had a strong attachment. In the same year he was elected a Foreign Correspondent of the Geological Society and a Foreign Member in 1877. He was made Copley Medallist by the Royal Society in 1903 and Wollaston Medallist by the Geological Society in 1896, and a Foreign Member of the Royal Society in 1904.

Professor Suess retired from the Chair of Geology after forty-four years active service, in his 77th year. In commemorating his 80th birthday on August 20, 1911, his friend Professor Steinmann delivered a eulogium on Professor Suess' work. He writes:—

"Far beyond his University, indeed wherever the sound of the German tongue reaches, the name of Eduard Suess will to-day be remembered with the profoundest esteem by every geologist and geographer, nay, almost by every naturalist as well . . .

"Scarcely any other investigator of modern times has influenced science so lastingly and deeply as Suess. For nearly half a century he devoted his mind to the great problem of the formation of the earth's surface and in tracing accurately the principles upon which it was founded. Relying largely upon his ample observations and experience in former years, his work *Antlitz der Erde*, from 'the Origin of the Alps' in 1875 up to its conclusion in 1910, is a unique memorial of scientific, synthetic reasoning. In a masterly way he gathered up his facts from innumerable articles, extracting what was of value even to the smallest paragraph, whether geological or palæontological. For, to his mind, every stone might contribute to the construction of that monumental edifice which he was erecting with such careful hands . . .

"To the congratulations of the Viennese Geological Society offered to him on the completion of the final volume of the *Antlitz* he replied, 'the merit of the chief part of the work belongs essentially to those workers who have sacrificed their vital powers to carry out those investigations which I have recorded.' His activity as a University Professor not only benefited his class, but quickly spread beyond the walls of the lecture-room to all who would lend a willing ear to the progress of that science which he so zealously taught. To-day Suess completes the 80th year of his life. How few scientific men are permitted to retire from active work in their full health and vigour and in the enjoyment of all their faculties. He can look back upon a happy life as an investigator and a teacher; as an active citizen of Vienna, as president for many years of one of the most eminent Academies, and as an elected Member of Parliament. The son, who is on the point of taking his father's place at the University, also gives promise of most excellent abilities." [1]

Of Professor Suess' publications the list would be too long to give, but one may mention, however, specially, the following :—

"Ueber *Terebratula diphya*": SB. k. Ak. Wiss. Wien, 1852. [His Brachiopod and Cephalopod work was continued in many papers until 1870.]
Ueber das Wesen und der Nutzen palaeontologischer Studien. Wien und Olmüz, 1857.
Der Boden der Stadt Wien . . . Wien, 1862.
Die Entstehung der Alpen. Wien, 1875.
Das Antlitz der Erde. Prag, Wien, und Leipzig, 1883–1909; in French, Paris, 1897–1911; in English, Oxford, 1904–9.

II.—On upright *Equisetites* Stems in the Oolitic Sandstone in Yorkshire.

By Dr. T. G. Halle, of Stockholm.[2]

(PLATE II.)

STEMS of *Equisetites columnaris* (Brong.) have long been known to occur in a vertical position in the sandstones of the Inferior Oolite on the Yorkshire coast. This mode of occurrence has commonly been held as proving that the stems are preserved in the position in which they once grew, having been buried in situ beneath the layers

[1] *Die Geologie an der Wiener Universität in den letzten 50 Jahren.* Ein Blatt des Glückwunsches und des Gedächtnisses von G. Steinmann. Aus Geologische Rundschau, ii, pp. 368–9, Leipzig, Wilhelm Engelmann, 1911, 8vo.

[2] Communicated by Professor A. G. Nathorst, LL.D., Sc.D., Ph.D., Keeper of the Department of Fossil Plants, Royal Natural History Museum, Stockholm.

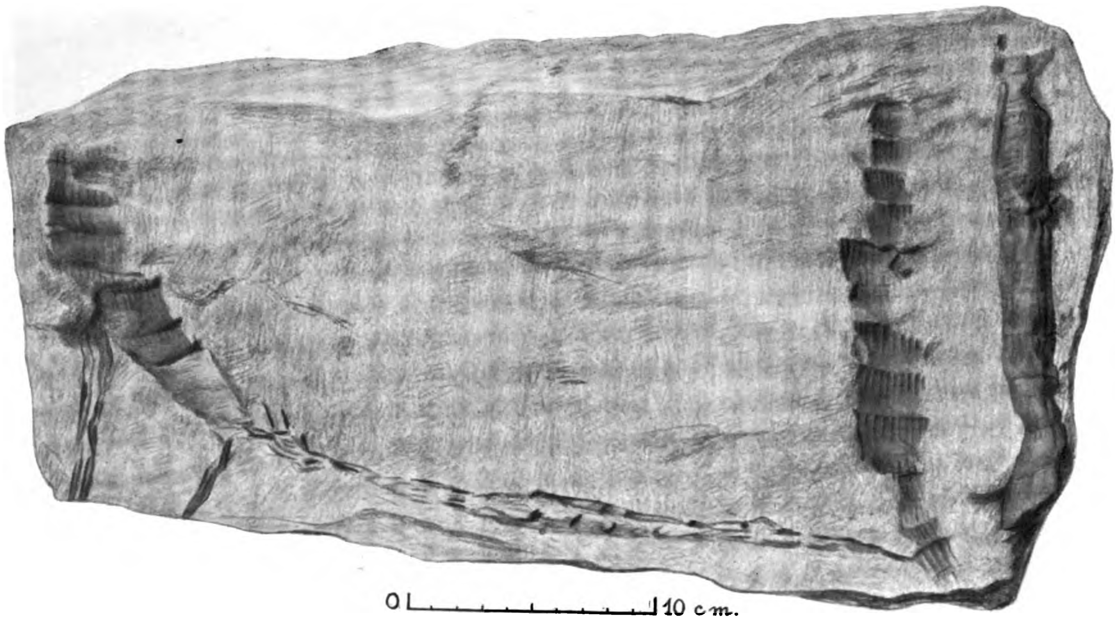
of sand that accumulated on the spot. On the other hand, it has been argued that the upright position need not be primary; it might be as readily explained if the stems are regarded as drifted and secondarily deposited on the spots where they are now found. It is well known and has been pointed out, particularly in the discussions of the upright stems in the Coal-measures, that a drifting tree often has a tendency to sink in a vertical position, the root-end being heavier because of adhering mineral matter or from some other reason. Phillips describes, in his *Geology of the Yorkshire Coast*, a locality at High Whitby where upright stems of *Equisetites columnaris* occur in the sandstone. He continues[1]: "They . . . are broken off or imperfect above, and seldom reach to the upper surface of the bed; they are also broken off below, but commonly pass to the lower surface; and some of the lower joints nearest the roots are found in the subjacent bed of shale." These facts have led, according to Phillips, to the conjecture that the plants grew in the shale "and were buried by an influx of sand and water". The other possibility, that the stems had been floating and deposited in vertical position, was at one time contemplated by Phillips, but he finally became convinced that "in several cases on the coast . . . *Equiseta* were prostrated and buried in abundance near to the spots where they formerly grew, and that here and there a few stems appear erect in the attitude of their marshy growth".

It would appear as if the idea of a preservation in situ of the upright *Equisetites* stems had been, in later years, discarded for the opposite one. Seward, who figures in his *Fossil Plants* a fine example of three upright stems in one piece of sandstone, expresses himself in the same work decidedly for the drift hypothesis.[2] The question does not appear to have received much attention lately, but it certainly deserves to be more studied both from a palæobotanical point of view and yet more because of its bearing on the mode of deposition of the sandstone. Many instances of occurrence of upright *Equisetites* stems have been noted by different geologists. It is not intended to give any review of the previous observations here; but the subject will be more fully treated by Professor P. Kendall in a paper following the present.

During a visit to the Yorkshire coast, in the summer 1910, for the purpose of collecting fossil plants, I paid, on the initiative of Professor A. G. Nathorst, some attention to the upright stems of *Equisetites columnaris*. The species is a very common one, and occurs in both the shales and the sandstones of the Lower and Middle Estuarine Series. In the shales the plant is mostly found as impressions or as very flattened casts lying on the bedding-planes. In the sandstones, on the other hand, it commonly occurs as upright cylindrical casts covered with a thin dark coating which often exhibits the teeth and other features of the leaf-sheaths. The vertical stems appear to be especially common in the sandstone cliffs of the Lower Estuarine Series along the coast from Whitby to Hayburn Wyke, but they are found also in

[1] J. Phillips, *Illustrations to the Geology of Yorkshire*, pt. i, The Yorkshire Coast, 3rd ed., p. 143, London, 1875.

[2] A. C. Seward, *Fossil Plants*, vol. i, p. 72, 1897.



Stems of *Equisetites columnaris* (Brong.) showing rhizomes. Lower Estuarine Sandstone, Inferior Oolite: Peak Alum Works, Yorkshire coast.

the Middle Estuarine Series, as for instance between Hayburn Wyke and Cloughton Wyke and at Scarborough.

The very abundance of the upright stems is perhaps rather in favour of the in situ hypothesis. This mode of occurrence is not only frequent but appears, in many places at least, to be the rule in the sandstone. The casts are often quite crowded and convey in a striking manner the impression of a fossil *Röhricht.*[1] A direct proof would be established, however, if rhizomes or roots of the plant were found to occur in connexion with the stems in such a manner that they must have grown into the sand. The stems are often seen to attain a considerable height in the rock, a couple of feet or more, and it is no doubt largely due only to the fact that the vertical surface of the sandstone cliffs generally does not quite coincide with the plane of the stems that these cannot be traced further. In some cases, however, the stems are found, when followed downwards, to disappear rather abruptly into an intercalated shaly layer, and it is then possible, as suggested by Phillips (l.c.), that their rhizomes have grown in that layer though they are usually not preserved. It is difficult, however, to establish a direct proof that such was the case.

Towards the end of my stay in Yorkshire, Professor P. Kendall, of Leeds, kindly conducted me to a place where he had discovered upright *Equisetites* stems occurring abundantly in the sandstone. The locality is at the Peak Alum Works close by the railway line between Robin Hood's Bay and Hayburn Wyke.[2] After a short search a few examples were found which appear to throw some light on the question. The best specimen, which is shown here in Plate II, was in a continuous wall of the cliff, but was broken out and is now in the collections of the Palæobotanical Museum at Stockholm. To the right are seen remains of two upright stems about 20 cm. high and with a diameter of 2–3 cm. From the lower end of one of these stems arises a lateral shoot or rhizome which continues for some distance almost horizontally at a right angle to the mother-stem, the horizontal portion being completely flattened and therefore looking very thin as seen from the side. About 25 cm. from the mother stem, this horizontal shoot begins to bend gradually upwards and continues in another upright stem. At the bend there arise from the shoot some sort of appendages, three in number, which cannot be anything but roots. These run in a downward course, and the two longest can be traced for a length of 7 cm. to the base of the piece of rock. The whole specimen is such that it cannot be satisfactorily accounted for except on the supposition that it is preserved in the position of growth. A branch has grown for some distance as a creeping rhizome and has then bent upwards to form another aerial stem. The roots arising at the bend must be taken to have grown into the sand, and it is probable that the sand had been accumulating all the time round the growing plant. I think this explanation must be admitted to be the more plausible one. To account for this complex specimen as drifted and later deposited would require the assumption of such improbabilities as might well be said to approach the impossible.

[1] Reed-bed.
[2] The stratigraphical conditions will be described in Professor Kendall's paper.

Another specimen is shown, on a larger scale, in Text-fig. 1. In this case there is a cylindrical cast which is not quite vertical but somewhat obliquely ascending. The cast is fairly thick, about 3·5 cm. in diameter, but only three internodes are preserved, with a length of about 10 cm. together. To two of the nodes, the one at the base and the second node above it, are attached horizontal branches, one to each node. The lower branch is very indistinct, being seen, in its flattened condition, only from the side. The upper branch lies on the upper surface of the piece of rock and can be seen from above. Its flattened cast has a breadth of 3–4 cm., and it can be traced for a distance of more than 16 cm. from the main stem to the edge of a piece of rock. Near the point of insertion of the branch there is seen what must be taken to be a root protruding obliquely downwards into the rock. Another root-like fragment is seen a little below a node near the middle of the horizontal portion. The main

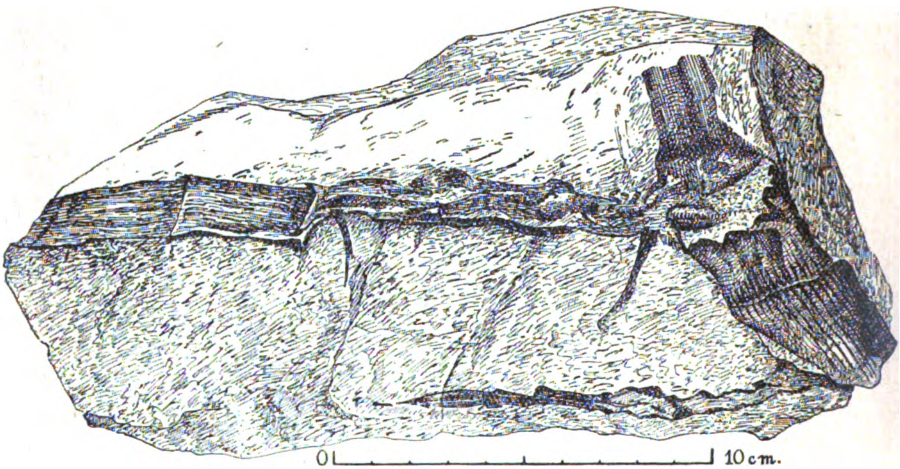


Fig. 1. Stems with rhizomes attached of *Equisetites columnaris* (Brong.). Lower Estuarine Sandstone, Inferior Oolite: Peak Alum Works, Yorkshire coast.

interest of this specimen is in the occurrence of creeping rhizomes at different levels above each other arising from the same stem. On the lower surface of the same piece of rock there is another horizontal, flattened cast, not shown in the Figure, which is no doubt a branch from the same stem, too, though the actual connexion is not seen. The horizontal portion has a length of about 20 cm.; then the branch bends upwards to form a new aërial stem, in the same manner as in the specimen figured in Plate II.

The features here described seem to indicate not only that the plants grew on the spot just as they are now found, but also that the accumulation of the sandstone proceeded while the plants were still growing. The sending out of creeping, root-bearing rhizomes from the upright stems at successively higher levels may be regarded as an attempt of the plant to hold its own against the overwhelming sand. Similar cases of preservation are known from the Carboniferous formation, and have generally been regarded as proofs of an occurrence in situ and as resulting from the even balance between the growth of the plant and the silting up of its habitat. Some figures of Coal-measure plants given by Grand'Eury illustrate practically the same conditions, especially one showing a very fine group of *Calamites Suckowii* from the Carboniferous of Central France; and Grand'Eury's interpretation of the structure of this specimen is similar to the one applied here to the Yorkshire *Equisetites*.

If this interpretation of the vertical *Equisetites* stems is right, it will be seen to throw some light on the conditions under which the surrounding sandstone was laid down. On the spots where the *Equisetites* stems grew during the accumulation of the sand, the water must have been comparatively shallow, as the tops of the stems, at least, reached above the surface. The vertical casts cannot, as a rule, be followed for more than a few feet, yet it appears highly probable that the same conditions of sedimentation prevailed during the accumulation of thick banks of sandstone. The two specimens figured here come from beds at different levels in one and the same section of the sandstone, and it may be concluded with some probability that the intermediate beds were formed in the same manner too. There is no reason to regard the cases here described as mere exceptions. I am inclined to believe, both from the descriptions of the older writers and from my own observations, that the upright stems of *Equisetites* which are so common in the sandstones as a rule have been preserved under similar conditions, in which case the sandstone too should have been deposited in a uniform manner. It would be natural to imagine that the *Equisetites* grew in large, shallow fresh- or brack-water lagoons or protected estuaries with low marshy shores, and that these lagoons or estuaries were gradually becoming filled up by accumulating sand, the area being, during this process, slowly subsiding. The whole question, however, requires much more extensive observations, and it certainly deserves to be made the subject of special studies.

III.—Notes on the Stratigraphical Position of Beds with *Equisetum*.

By Professor Percy Fry Kendall, M.Sc., F.G.S.

Dr. NATHORST mentioned to me in 1910 the fact that the rhizomes of *Equisetum columnaris* had not been observed, and I offered to show him a place where I thought they would be found. He had not time to visit the section on that occasion, but in the following year Dr. T. G. Halle accompanied me to the exposure and agreeably to expectation the rhizomes were found within a few minutes of our arrival.

The section is exposed at the Peak Alum Works (now Brick-works), where a splendid sequence is exhibited, extending from the Alum

[1] C. Grand'Eury, *Flore Carbonifère du Département de la Loire et du centre de la France*, Paris, 1877, p. 15, pl. i, fig. 1.

Shales (*Dactylioceras commune* zone) of the Upper Lias to the overlying Dogger Sandstone and Lower Estuarine Shales and Sandstones.

The succession is as follows:—

		ft.	in.
Lower Estuarine Series (71 ft. 2 in.).	Soil and rubble	4	0
	Sandstone	4	0
	Shale	4	0
	Sandy shale with boxstone concretions	5	0
	Splintered sandstone	6	0
	Raggy sandstone	3	6
	Grey and black carbonaceous shale	13	0
	Raggy sandstone with many rootlets in the upper part and erect stems of *Equisetum* in the lower 3 feet	4	6
	Sandy fissile shale with rhizomes of *Equisetum* and poorly preserved fronds of *Williamsonia*	1	0
	Grey shale without marked bedding, much resembling a Coal-measure 'seat-earth'	4	0
	Shale	7	0
	Nodular and ferruginous shale	3	0
	Coarse, massive, ferruginous sandstone	2	4
	Massive sandstone pierced with many vertical roots	2	3
	Compact sandstone	0	7
	Fissile sandy shale	1	0
	Black shale	6	0
	Dogger, very ferruginous columnar sandstone with pebbly base	3	0
	Upper Lias		

The Dogger Sandstone is unfossiliferous in this section, but its lithological characters are unmistakable. The columnar jointing is in many places extremely close and well-marked, the polygonal columns in some examples being not more than two or three inches in diameter. The pebbles at the base appear to be rounded concretions, probably derived from the Upper Lias. Some show small spheroids that may be of an oolitic character and remind me of the more sparsely oolitic varieties of the Cleveland Ironstone, to which I may have mistakenly ascribed pebbles in the Dogger at Wain-Stones (see Mr. Rastall's paper on the Dogger, Q.J.G.S., vol. lxi, 1905).

It is interesting to note that this section is the exposure of Dogger nearest to the Peak Fault that brings in a greatly expanded development of this division of the Lower Oolites, as well as Blea Wyke Beds and the *Striatulus* shales of the Upper Lias, no representative of which are found on the upthrow side of the fault.

The Lower Estuarine Beds present a strong resemblance to a section of Coal-measures, and were no doubt deposited under analogous condition; the chief difference between them is in the less degree of induration of the newer series. The *Equisetum* bed is easily recognized from the level of the railway (Scarborough and Whitby line) that passes through the quarry as the second bed of sandstone above the Dogger. Sandstone casts of *Equisetum* stems in the erect position pierce the sandstone in large numbers; some fallen blocks show transverse sections on the bedding-planes every 8 or 10 inches. Stems may be traced to a length of 18 inches. The top ends are commonly twisted as though they had been wrenched round and bent over. A careful search in the overlying shale has so far failed to discover the much-desired fruits of the *Equisetum*, but I do not despair of finding them either here or at Blea Wyke. An exactly similar bed may be observed at about the same height above the Dogger beside the footpath descending the cliff in the re-entrant angle at Blea Wyke. The erect stems are contained in a strong bed of sandstone, and the flattened rhizomes occur in an underlying black shale in which many well-preserved fronds of *Williamsonia* occur.

I am indebted to my friend Mr. J. T. Sewell, J.P., of Whitby, for the following note, which shows that this is not the first record of the occurrence of rhizomes of this *Equisetum*:[1] "In one part of these cliffs was pointed out a place where a bed of sandstone, high up in the cliff, contains stems of reeds (correctly speaking these plants appear to be allied to the Equisetaceæ). These are an inch or more in diameter and 2 or 3 feet long, standing upright in the sandstone, while the shales below contain the traces of their roots." I suspect that the place alluded to is near the "Jackass Road" at Hawsker, whence the late Stephen Palmer used to obtain for me what he styled "pieces of cain" (cane).

IV.—The Physical History of the Norwegian Fjords.

By Professor Edward Hull, LL.D., F.R.S., F.R.G.S.

The Scandinavian Promontory.—This remarkable promontory, extending for over a thousand miles from the Naze to the North Cape, is formed mainly of Archæan rocks, consisting of gneiss, crystalline schists, and other metamorphic rocks, penetrated by granite and other igneous dykes of later date. These primeval rocks are overlain throughout a portion of their extent by Cambrian and Lower Palæozoic (or Lower Silurian) beds, between which and the Archæan masses there is entire discordancy, and, as regards their respective ages, a long period of unrepresented time. The Palæozoic beds are themselves highly altered when in contact with the intrusive igneous masses, so that it is difficult to distinguish them from the more ancient masses in some districts.

The older rocks are azoic, the later are fossiliferous.

These combined masses constitute a truncated ridge or plateau of rocks all rising into their highest elevations[2] towards the Atlantic coast and breaking off abruptly in stupendous cliffs traversed by deep and narrow channels, down which streams rising in the central snowfields pour their waters into the Atlantic; while in the other direction the general surface slopes down with a more gentle declivity towards the shores of the Gulf of Bothnia and the Baltic Sea. In consequence of this conformation of the surface the river

[1] Report by Sir Charles Strickland, Bart., of an Excursion by Tug-boat from Whitby to Peak of members of the Brit. Assoc. (York Meeting): Report of the Whitby Lit. and Phil. Soc., October 28, 1881.

[2] Snehætta reaches 7,615 and Galdhöpiggen 8,399 feet.

channels are less deep and precipitous on the eastern or Swedish side than on the western or Norwegian side of the peninsula, and the watershed approaches the western coast and is nearly conterminous with the boundary between Sweden and Norway.

The special interest regarding the Norwegian fjords is concentrated on those entering the Atlantic, and is not repeated in any other part of Europe. It is here, and nowhere else, that the waters of the ocean find their way up into the very heart of the mountains, the summits of which are covered by perennial snow giving rise to the streams which enter the fjords at their upper limits; and it is in Norway, and nowhere else, that the glacial ice falls directly into the waters of the Atlantic, as is the case with the Jökel Fjord, where detached masses of ice float away on the ocean surface. It is in Norway also that we find the largest snowfield of Europe, in the Jostedalsbræ, which is estimated to have an area of 580 square miles.[1]

From what has been said it will be evident that the fjords are continuous with the rivers draining the interior snowfields and glaciers, and are to be considered as partially submerged river valleys, or, as designated by Lord Avebury, "drowned river valleys."[2]

We have now to consider the process which has eventuated in the formation of these unique physical features.

The Archæan ridge in all probability formed part of a great primordial land barrier ranging along the Arctic Ocean in pre-Silurian times; but it is impossible to suppose that any of the streams now entering the Atlantic from Scandinavia had their origin at this period. However this may be, there can be no doubt that they drained a land surface from the Silurian period downwards throughout the whole of the vast lapse of time represented by the Mesozoic and Tertiary formations. These formations have no representatives in Scandinavia; and in their absence we may assume they were not deposited upon the submerged surface of the older formations. It is far more probable that the peninsula remained as unsubmerged land throughout the succeeding geological periods; and throughout this vast lapse of time the rivers which drained into the ocean were eroding their channels. This at any rate is the view I find it necessary to take, as it helps us to understand how, amidst rocks of such hardness as those of Norway, channels of the depth we contemplate, both emergent and submerged, were eroded; and have thus produced the lofty cliffs which rise from the banks of the streams and excite our admiration and astonishment: such are those of the Romsdal, the Gudvangen, and the Stalheim, rising from 2,000 to 4,000 feet on either hand from the river banks.[3]

The Fjords.—We shall now turn our attention to some of the fjords which I have myself visited and which, with the aid of the soundings on the Admiralty Charts, excite surprise by the depths to which they

[1] *Encyc. Brit.*, 11th ed., vol. xiv.

[2] *The Scenery of England*, 1901, p. 101.

[3] Professor J. W. Spencer has remarked that many of the sharper peaks and precipitous cliffs owe their form to the peculiar climatic conditions of Norway—the frosts of winter and long days of summer.

descend below the surface of the ocean-water with which they are filled; they are those known as the Sogne, the Hardanger, the Volden, and the Nord.

The Sogne Fjord is by far the largest of the Scandinavian sea-locks entering the Atlantic, and drains a very extensive area of mountain land. By means of the isobathic lines contoured from the sounding on the charts, one gains almost at a glance the form of the channel in which the water lies. Entering from the outer ocean with a comparatively shallow depth, the floor is found to descend rapidly downwards till it reaches to almost 4,000 feet (665 fathoms) below the surface, a depth which it retains for a considerable distance, only becoming shallower as it approaches the upper limit of the submerged channel, where it receives the waters of the rivers descending from the interior snowfield. The maximum depth is seen to occur where the fjord is bounded on either hand by mountain masses of great extent and elevation. Similar phenomena characterize the other fjords I have named above, and need not be repeated. They all increase in depth inwards from their outlet amongst the islands which follow the coast from south to north throughout its greater extent. This form of channel evidently requires explanation, being altogether different from that of river valleys elsewhere, which necessarily, in flowing from their sources to their outlets, descend from higher to lower levels.

The following are the depths to which some of the fjords reach towards the centre of their range between their outlet and their source:—

	Fathoms.	Feet.
The Sogne (about)	665	4,000
,, Hardanger	425	2,550
,, Volden	383	2,298
,, Nord	300	1,800

Assuming then, as I have done, that the fjords are partly submerged valleys of rivers which originally entered the Atlantic or the Arctic Oceans, it is clear that they could only have been eroded when they were in the condition of land surfaces—as rivers never erode their channels under the waters of the ocean.

As soon as rivers enter the ocean their erosive action ceases, and the force of the streams is dissipated. We must therefore suppose in the case of the Norwegian Fjords an uprise of the whole area to an extent of several thousand feet above the present level (in reference to that of the ocean) at a time when rivers flowed down them, and as such they must have had ever-deepening channels throughout their course. This is quite in accordance with the form of the river valleys of Western Europe which entered the ocean in recent Tertiary times.[1]

The Glaciation of Norway.—In order to account for the peculiar form of the channels it is necessary to invoke the effects of glacial snow and ice under its two heads; first, the erosive action of the ice itself, which, carrying in its mass fragments of rock, or sand, and under the pressure of thousands of feet of ice, wears down the floor

[1] As I have shown in my recently published monograph, *On the Sub-oceanic Physiography of the North Atlantic Ocean* (E. Stanford), 1912.

of the valley as it moves seaward; or second, the power of the ice in piling up masses of moraine matters on reaching the chain of islands which follows the coast from Stavanger (lat. 59°) to the Trondhjem Fjord. This, I understand, is the more favoured explanation with the Scandinavian geologists.

It is almost unnecessary to state that during the Glacial Period the whole of Norway and Sweden was covered deep with snow and ice, except where lofty peaks thrust their heads above the vast ice-field of the interior.

Those who are unfamiliar with the results of glacial erosion either in past or recent times in Scandinavia, the Alps, or the British Isles, in wearing down the surfaces of the hardest rocks into hummocky forms called *roches moutonnées*, or covering the surfaces with grooves and striæ, and transporting blocks of rock to great distances from the central snowfields and scattering them over the plains, can little realize the extent to which the glaciers of this region covered the lands and invaded the ocean bed during 'the Great Ice Age' of post-Tertiary times. The Norwegian ice, during a period of great elevation, descending in both directions filled the fjords, also the North Sea and, to a varying distance, the Atlantic, and meeting the ice descending from the Scottish Highlands caused it to change its course, while both together swept round the coast of Scotland and entered the Atlantic, where it was broken up and dissolved by the warm waters of the Gulf Stream.[1] On the other hand, the ice descending over the plains of Sweden filled the Gulf of Bothnia and the Baltic, and invaded the plains of Russia and neighbouring countries. During a recent visit to the Baltic I was everywhere greatly impressed by the evidence of the former action of the great ice-flow in moulding the surface of the rocks, and transporting from distant sources blocks of granite or other rocks which lie on the surface or have been turned to use for walls and buildings.

It can scarcely be doubted that on the Atlantic side this ice must have eroded the surface and deepened the beds of the fjords; and this view is confirmed by the fact that (as in the case of the Sogne Fjord) the position of maximum depth of nearly 4,000 feet is just where the fjord is bounded on either hand by mountains of great extent and elevation, and where in consequence the ice would accumulate in greater mass and be most effective in eroding the bed of the glaciers.

I conclude, therefore, that the ice of the Glacial Period has been an agent in deepening the channels of the valleys, but to what extent it is impossible to say, as we are not certain to what extent the piling up by moraine matter in the passage through the chain of islands has decreased the depth of the channels. We may, however, conclude that both these agencies have combined to produce the remarkable conformation of these wonderful sea-locks which give to the fjords their special interest. They are, as far as I am aware, reproduced nowhere else.

[1] This remarkable movement of the ice was first recognized by Professor James Geikie, and is shown in plate vii of the Monograph of the British Isles above quoted.

The Post-Glacial Subsidence.—The phenomena above described occurred during a period of high elevation, and was succeeded by one of corresponding depression, accompanied by a return of milder conditions of temperature and gradual disappearance of the ice from the fjords and lower regions of Scandinavia. In my view it was these changes of level which were the direct cause of the Glacial Epoch.[1]

The evidences of depression of the land are apparent in many places throughout Norway in the presence of old sea-beaches, containing marine shells of existing species, at levels of several hundred feet above the sea-waters. According to Reusch and Hansen, these terraces occur at levels of about 200 metres (615 feet) in the Christiania and Trondhjem districts, in front of the lakes of the east country forming large plains; but are generally at lower levels, sloping distinctly from higher positions in the interior of the fjords to lower levels towards the outer coast.[2] The terraces are composed of reconstructed glacial matter consisting of sand, gravel, and boulders, and the marine shells found in the glacial clays show a transition from the cold Arctic, to that of a milder, climate of the present day. Considering that the waters of the sea must have penetrated much further inland than at the present day, and that the conditions of the glacial stage were only passing away, we may suppose that the glaciers in many places actually entered the fjords, and gave rise to icebergs, which floated into the ocean waters, and on melting scattered their contents of mud and stones over the ocean bed. In this way we may account for the spread of glacial detritus over the floor of the North Sea, filling up the submerged channels of the rivers; and owing to this it is that the river valleys are seldom traceable by means of the soundings at the present day on the Admiralty charts.

Epoch of Re-elevation.—We now come to the consideration of the final stage upon which the peninsula entered in order to give rise to the relations of land and water now represented with admirable correctness on our charts. Re-elevation of the land was necessary for this result, but to a far less extent than that we have previously had to deal with. It was a case of a few hundred feet against several thousand, resulting in adding large areas of land along the margin and islands bordering the continent. Sweden must have gained enormously by this elevatory process, and many islands arose where the waters previously prevailed.

It is not my intention to discuss the question how these movements of the crust were brought about; this is a geological problem which physicists will solve in various ways. All I have to say is that it was not due to volcanic action, but is to be explained in accordance

[1] This is the view which I have endeavoured to develop in my monograph above alluded to, and I hope successfully. Judging by the results obtained by the soundings, the submerged river-channels descended to over 1,000 fathoms (6,000 feet), which gives the amount of the uplift of the land above the present level of the ocean. But for full evidence of this conclusion the reader is referred to the monograph itself.

[2] According to Professor James Geikie, quoting from Erdman, the terraces are found at levels up to 800 feet or more above the surface of the sea. (*Great Ice Age*, p. 388.)

with terrestrial movements which have occurred from time to time throughout all geological history. But, in order to measure the movements, it has been necessary to recognize the level of the ocean as a datum for reference in accordance with the views of our great master Lyell. But I would only point out that however great the oscillations of the crust may appear to us living on its surface, they will appear extremely diminutive when measured by the length of the earth's radius, which is the true standard of measurement.

V.—North American and European Drift Deposits.

By R. M. Deeley, M.Inst.C.E., F.G.S.

(WITH A FOLDING TABLE.)

THE classification of the drift deposits is one which has given rise to very divergent views. One school holds that the Glacial Period was marked by increasingly severe conditions of climate followed by a somewhat regular amelioration. Another school holds that it consisted of a series of cold periods separated by warm intervals. It is not contended that in Pleistocene times the ice disappeared completely; for it is pretty certain that on high mountain ranges, and in the Arctic and Antarctic areas, snow-fields and glaciers existed continuously. With cold conditions the ice-covered regions spread from the Polar areas and glaciers descended from the mountains, and with the return of warmer conditions the Polar glaciers and ice-fields decreased in area whilst the mountain glaciers again retreated up the valleys. The problem as to the extent to which such variations in glacial conditions occurred, and the number of times they recurred, can only be settled by a study of the Pleistocene deposits themselves. In this matter theory cannot at present help us.

During recent years much work has been done which has an intimate bearing upon the question, and several geologists have given their views on the subject of the classification of the drifts. In North America, where drift deposits are especially well developed, our knowledge of them has been greatly increased by the work of Salisbury, Chamberlin, Calvin, Wiedman, Upham, Calhoun, Tarr, Gilbert, Coleman, Stone Alden, Leverett, and many others. In the European Alps and North-West Europe, Penck, Bruckner, Suess, Hess, Forel, Wahnschaffe, Keilack, French, Credner, Emil Werth, Klantzsch, Berg, and many others have done a great deal in the classification, description, and mapping.

In 1895 James Geikie [1] gave us a classification of the glacial deposits in which he attempted a correlation of the North American with the European deposits, whilst Frank Leverett [2] in 1910, in the light of more recent work, has again dealt with the question in some detail. His paper is printed in English.

Leverett spent the year 1908 in Western Europe in a study which had for its aim a comparison and tentative correlation of the glacial deposits in that area with those of the United States, on the study of

[1] *Journal of Geology*, vol. iii, pp. 241–69, 1895.
[2] *Zeitschrift für Gletscherkunde*, vol. iv, pp. 242–95, 321–42, 1909–10.

which he had been engaged since 1886. In this European study about three months were spent in making the circuit of the Alps. The several drift sheets were studied under a variety of topographic conditions. Several months study in the North German lowland extended from the Russian boundary westward to the Netherlands. The limits of the last glaciation and of the next older glaciation, as well as the characteristics of each of their drifts, compared with a still older drift, exposed in recesses of the mountains along the south side of the lowland, were leading subjects of study. In Great Britain the study consisted of a few trips only along the eastern coast and brief visits to the interior. This will account for the small notice taken of British Pleistocene deposits.

Leverett remarks: "It would be presumptuous for one to pretend to clear up the matter of worldwide correlations of glacial deposits in a single year's study; and no one perhaps realizes better than does the writer what a small start can be made in this brief time. A full correlation, however, may in time be reached by repeated efforts of this sort. Even though tentative it seems worth while at this time to state what impressions and results were obtained."

In Table I are given in outline the main results arrived at by Leverett. Nos. 1, 2, 3, and 4 are the four well-marked cold periods, whilst A, B, and C are the interglacial warmer periods. For fuller details the paper itself should be referred to. Attention may be called to the fact that both in North America and on the continent of Europe, the trend of glacial work is to support the view that there were at least four cold periods separated by long warm intervals. J. Geikie has shown that even after the Wisconsin–Würm period there were climatic oscillations, probably of short duration, which led to considerable increases and decreases in the size of valley glaciers. This view is also held by Swiss and German geologists of note.

Penck and Bruckner[1] show that during each of the four cold periods when the glaciers debouched upon the foreland enormous quantities of gravel and sand were thrown out over the country, filling up and obliterating all traces of many valleys. These outwash gravels were formed when the mountain valleys were filled with great glaciers and were grinding and plucking the rocks upon which they rested. The fine rock flour found its way down the rivers to the sea.

During each interglacial stage, when the glaciers had almost wholly melted away, the rivers cut deep valleys through the outwash gravels. Thus valleys were eroded during warm periods and again filled by outwash gravels during cold periods. There is very good evidence that during the four main glacial periods the precipitation of moisture was about the same as that during the warm periods, and that the development of the glaciers was almost entirely due to fall of temperature.

We, therefore, see that during the glacial periods the rivers were so charged with debris that they could not transport it at normal gradients, and, as a result, they deposited pans of outwash material. With the disappearance of the great glaciers great erosion ceased, and

[1] *Die Alpen Ciszeitalter.*

DIAGRAM TO ILLUSTRATE GRAPHICALLY THE GLACIAL AND INTERGLACIAL PERIODS.

(After Penck and Bruckner.)

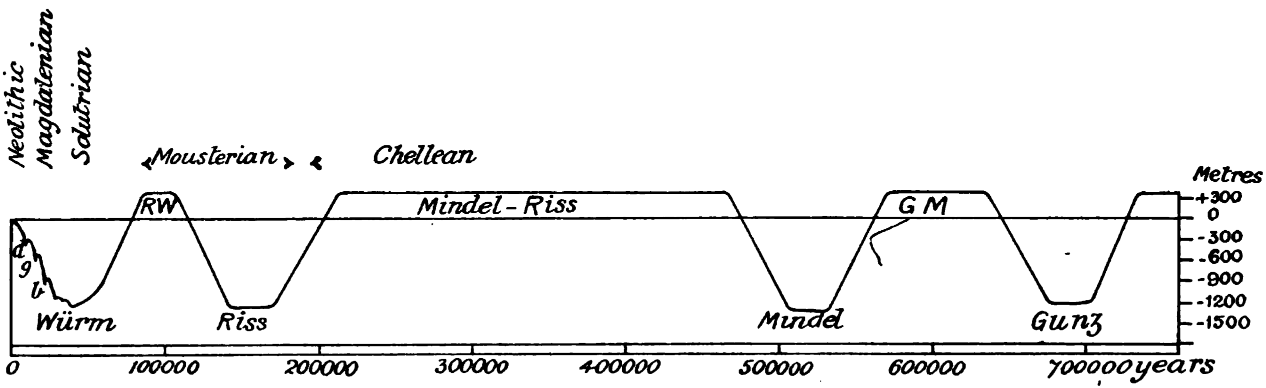


FIG. 1.

Glacial Periods: Würm, Riss, Mindel, and Gunz. Stages: *d* Daun, *g* Gschnitz, *b* Bühl.
Interglacial Periods: RW. = Riss-Würm, Mindel-Riss, GM. = Gunz-Mindel.
Culture stages of man: Neolithic, Magdalenian, Solutrian, Mousterian, and Chellean.
Ordinates show variations in height of snow-line. Abscissæ show estimated ages in years.

the rivers were again able to re-excavate valleys through the outwash deposits; terraces and plateaux of these gravels now overlook the river courses.

Penck[1] has given an excellent description of the erosive action of glaciers, showing how the recognized features of glaciated mountain regions have been produced.

Concerning the duration of the Glacial Period as a whole an interesting diagram is given by Penck & Bruckner,[2] the main features of which appear in Fig. 1. It must be remembered that many geologists have been induced to consider the Glacial Period of short duration because calculations based on the temperature gradient of the earth's crust appeared to show that the habitable age of the earth was between fifty and one hundred million years. But the discovery of radium and its heating effects have served to show that this view was based upon incomplete data. We may, therefore, give full weight to geological evidence when dealing with the age of deposits or periods. Penck & Bruckner do not contend that they have done more than make an estimate, and, although their estimate may be either too great or too small, it has been made with a very full knowledge of the Alpine phenomena.

The scale in metres at the end of diagram, Fig. 1, gives the height to which the snow-line was raised or lowered as a result of the changes of temperature, whilst the scale at the bottom shows the estimated age in years.

During the retreat of the ice of the Würm Period pauses and readvances took place. Three of these stages, the Daun (*d*), Gschnitz (*g*), and Bühl (*b*), shown on the diagram, have been clearly recognized in many localities. Above the diagram, the position of several of the stages which marked the advancing culture of man is shown.

A large number of moraines, showing halts or readvances of the Wisconsin ice-sheet in North America, have been mapped and described among others by Leverett.

VI.—Spilite Lavas and Radiolarian Rocks in New South Wales.

By W. Noël Benson, B.Sc., Emmanuel College, Cambridge.

THE very interesting remarks made by Messrs. Dewey and Flett on "Some British Pillow-lavas and the Rocks associated with them"[3] have further emphasized Dr. Teall's observation of the intimate association of Radiolarian rocks with lavas of this character, and which is particularly well developed in Europe in the later Devonian formations. It is further shown that such rocks are characteristic of areas of continuous off-shore subsidence, and are often intimately associated with intrusions of dolerite, quartz dolerite, gabbro, and serpentine.

Perhaps no occurrence of Radiolarian rocks is more often cited than

[1] *Journal of Geology*, vol. xii, pp. 1–19, 1905.
[2] *Die Alpen in Ciszeitalter*, vol. iii, p. 1168.
[3] Geol. Mag., 1911, pp. 202, 242.

that in the Tamworth District of New South Wales described by Professor David and Mr. Pittman, for these give clear evidence of their origin in comparatively shallow water.[1] The occurrence of spilitic rocks among these also has now been determined. Recently the writer has surveyed the greater portion of the Great Serpentine Belt of New South Wales, which extends from Bingara and Warialda, more than a hundred miles N.N.W. of Tamworth, to beyond Nundle, over thirty miles to the S.S.E. of the same town. A detailed description of this very interesting and diversified area is now in preparation. The following will here suffice to indicate the main points pertaining to the present subject.

The general sequence of the pre-Permo-Carboniferous formations observed is stated below. The series appears conformable throughout. The figures given are the apparent thicknesses only, and serve merely to indicate how great are the masses of sediment involved. Doubtless much repetition by faulting has occurred, particularly in the older formations, but at present it is impossible to estimate to what extent this is present. The sequence is as follows:—

Rocky Creek Conglomerates.—These are conglomerates and sandstones, interstratified flows of rhyolite and trachyte, and felspathic tuff beds. They contain ***Ænimites ovata*** and ***Lepidodendron veltheimianum.*** Their age is considered Middle Carboniferous, and the thickness is certainly more than 2,000 feet.

Burindi Mudstones.—These are composed of evenly bedded mudstones and occasionally limestones containing a rich Lower Carboniferous marine fauna. The thickness is about 1,500 feet.

Barraba Mudstones.—These consist of mudstones and clay stones with frequent Radiolarian bands differing from the non-Radiolarian beds chiefly in their somewhat finer grain size. Frequently bands of andesitic or felsitic tuff are present, also lenticles of non-fossiliferous argillaceous limestone. ***Lepidodendron australe*** is abundant. Their age is probably Upper Devonian. Their thickness is very great, *apparently* exceeding 13,000 feet. They have a wide distribution, covering more than a thousand square miles.

Baldwin Agglomerates.—These are course agglomerates with rounded pebbles of most of the older rocks set in a tufaceous matrix of felspar and augite crystal fragments, chips of spilite, etc. Occasionally narrow, rapidly chilled, spilite flows are interstratified, and rarely bands of very fine-grained felspathic chert containing Radiolaria. These beds commence near Tamworth (Cleary's Hill agglomerates of the previous authors), increase in thickness to over 1,800 feet, and die out again near Bingara, about one hundred miles to the north. Their age is assumed to be Upper Middle Devonian.

The *Tamworth Series* comprises Radiolarian banded cherts and claystones, fine and medium-grained tuff, of a composition similar to the matrix of the Baldwin agglomerates, but with smaller grain size. A well-marked coral limestone occurs, with an abundant Middle Devonian fauna,[2] sometimes as a string of small lenticular masses, sometimes a broad band. Spilite flows are numerous. They

[1] Quart. Journ. Geol. Soc., 1899, pp. 16–37.
[2] R. Etheridge, jun., Records Geol. Survey N.S.W., vol. vi, p. 151.

are especially noteworthy at Bowling Alley Point, near Nundle. The apparent thickness is about 10,000 feet, of which the portion of the series developed at Tamworth forms a little more than the upper half. It is believed the thickness given previously for this portion should be reduced.

The ***Woolomin Series*** consists of red jaspers with Radiolaria, claystones, tuff, and spilites, all in a very altered state. Its extent is large and stratigraphy greatly disturbed. Age, Lower Devonian.

The general sequence of geological events is believed to be as follows:—

Deposition of Woolomin and Tamworth Series took place on a sinking coast, and was interstratified with numerous spilite flows and layers of tufaceous material. Increase in igneous activity in

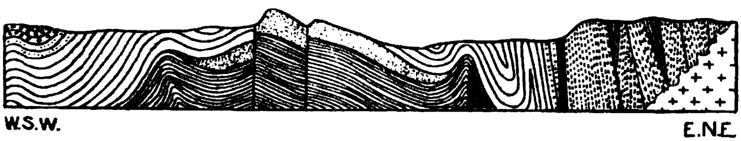


FIG. 1. Generalized Section, Northern Type, about 30 miles long.

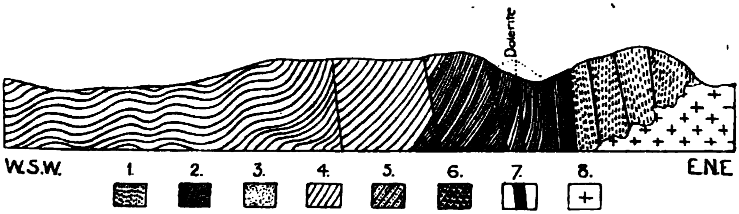


FIG. 2. Southern Type, about 20 miles long.

1. Woolomin Series.
2. Tamworth Series.
3. Baldwin Agglomerate.
4. Barraba Mudstone.
5. Burindi Mudstone.
6. Rocky Creek Conglomerate.
7. Serpentine.
8. Granite.

the central region brought about the deposition of the Baldwin agglomerates. In the south this activity was expressed by the intrusion into the Tamworth Series of great sills of dolerite and quartz dolerite often very coarse-grained. These are also known in the northern region, but have not yet been so fully studied. Except for occasional bands of tuff and fine breccia, igneous activity was slight in the Barraba times and temporarily ceased in the Burindi era. Orogenic movement commenced in Middle Carboniferous, and was expressed by the heavy conglomerates and the flows of acid lava. This movement (a thrusting directed from the E.N.E.) tilted the strata vertically and slightly overturned them. A great mass of peridotite was intruded into these upturned strata along a line of fault which runs throughout the length of the Radiolarian Series, and has been traced to fifty miles south of Nundle. A sill or dyke of serpentine thus runs intermittently for nearly two hundred miles. Pebbles of this serpentine occur among the Permo-Carboniferous series in the Newcastle District to the south, and Jurassic sandstone lies horizontally on its denuded surface.

Following the peridotite intrusions (with which came a minor amount of eucrite-gabbro) were minor intrusions of dolerite followed by a sequence of granitic intrusions that extend into the early Mesozoic. (See Figure, p. 19.)

The spilite lavas are similar to those described by Messrs. Dewey and Flett. They are dense, fine-grained, often more or less vesicular. In texture they are trachytic or pilotaxitic, with a varying amount of augite and magnetite among the felspar laths. According to the character of the occurrence the rock will have well-formed or skeleton crystals of felspar and iron ores, less rarely is the pyroxene well-formed. A partly devitrified base may be present; more rarely the rock is holocrystalline. Usually the augite is entirely changed to uralite and other products, and the felspar indeterminable through clouding with sericite chlorite, epidote, etc. Where determinable the felspar is invariably albite-oligoclase. The following chemical analyses will serve to show the affinity with spilites of Cornwall. As will be seen, this similarity descends even into such a minor point as the absence of barium.

	I	II	III	IV
SiO_2	48·22	48·58	47·56	53·17
TiO_2	2·68	1·77	2·40	1·85
Al_2O_3	14·82	14·58	14·27	9·36
Fe_2O_3	·56	1·89	1·63	1·29
FeO	9·25	7·65	6·80	9·62
MnO	·23	·46	·30	·19
MgO	5·58	6·36	4·90	9·00
CaO	8·81	9·80	10·95	7·46
Na_2O	4·95	4·02	4·61	4·26
K_2O	·44	·43	·27	·48
$H_2O +$	2·54	2·93	2·65	1·80
$H_2O -$	·15	·68	·42	·07
CO_2	1·40	1·00	2·95	1·17
P_2O_5	·23	·19	·19	·12
FeS_2	·37	·26	·22	·30
BaO	n.f.	n.f.	n.f.	n.f.
SrO	tr.	—	—	—
Cr_2O_3	n.f.	—	—	n.f.
$NiCoO$	0·3	·03	·08	·04
Fe_7S_8	—	—	·05	—
	100·26	100·63	100·25	100·18

I. Spilite, Nundle, New South Wales (analysed by W. N. Benson).
II. ,, Mullion Island, Cornwall (analysed by W. Pollard).
III. ,, Tregidden, Cornwall (analysed by E. G. Radley).
IV. Albite dolerite, Bingara, New South Wales (analysed by W. N. Benson).

The dolerites associated with the spilites are similar to those occurring with spilites in other localities. While in certain rocks, particularly those containing quartz, the plagioclase is andesine, in others it is nearly pure albite. They are often strongly titaniferous, and may contain a good deal of apatite and primary pyrites. The augites are more or less uralitized.

Another point of interest in connexion with these Australian spilites may be mentioned. About a mile north of the point where the analysed specimen occurred spilite is found associated with coral limestone containing fragments of recognizable coral. The microscopical structure has every indication of rapid cooling.[1] This seems to show clearly that spilite lava has flooded over a living coral reef and is not therefore necessarily a deep-sea lava. Radiolarian beds occur above and below this curious association of lava and limestone.

The Sedgwick Museum, Cambridge.

VII.—The Upper Trias of Leicestershire.

By A. R. Horwood.[2]

Part I.

1. General Description of the District.
2. Summary of Previous Work.
3. Stratigraphy of the District.

Part II deals with Physiography, Tectonics, Petrography and Lithology, Palæontology, Economics and Water Supply, Sections, Bibliography, Appendix.

1. General Description of the District.

The Upper Trias of Leicestershire as a whole occupies the western half of the county, being bounded on the east more or less by the Soar Valley, following the strike (as a subsequent in part of its course up to its junction with the Wreake). In fact, it is on the eastern boundary near the outcrop that the beds are mainly best exposed, the region to the west south of the coal-field around which it mantles being little developed and presenting fewer exposures.

The area under consideration is not less than 300 square miles in extent. It reaches from the River Trent, the northern boundary, to the Watling Street in the south, and from the eastern boundary, roughly coinciding with the Soar Valley and Midland Railway, to the western boundaries of the county, adjoining contiguous tracts of Trias in Warwickshire and Staffordshire. There are two main outcrops within this area of older rocks, the Carboniferous and Permian rocks, with Bunter in the north-west, between Moira and Ashby-de-la-Zouch, and the Charnian range of hills of Pre-Cambrian rocks 5 miles north-west of Leicester. Outlying outcrops of syenite between Hinckley and Leicester in the south, and of granite at Mountsorrel, Buddon Wood, etc., north-west of Leicester, also rise up as knolls in the Red Marl area. Elsewhere glacial deposits cover the Trias, especially south and east of Charnwood.

The Lower Keuper follows the Permian and Bunter outcrops on three sides of the Ashby Coal-field, and on the north side encircles the Charnwood Hills, where it rises to some height at Longcliffe and other points, and forms marked features elsewhere.

The Red Marl occupies the largest portion of this area. It forms the flat plain, little diversified except by syenitic knolls, such as

[1] W. N. Benson, "Preliminary Account of the Geology of the Nundle District, N.S.W.": Report of the Australian Association for the Advancement of Science, 1911, p. 101.

[2] Aided by a grant from the Government Grant Committee of the Royal Society.

Croft, between Nuneaton and Hinckley to the south. It, however, rises to considerable altitudes in the Charnwood region, filling the ancient valleys, and at Bardon Hill fills fissures in the older rocks at 880 feet in the Siberia quarry. At Leicester it is at levels of 100 feet O.D., and further west between Hinckley and Coalville maintains a height of 500 O.D.

The Upper Keuper Sandstone, again, in the same way as the Lower Keuper Sandstone, makes a feature around Leicester, at Ratcliffe and at Croft. So do beds lower down at Orton and Kegworth.

The Tea-green Marls at the outcrop, which is never extensive, form gently rising slopes up to the modified escarpment of the Rhætic beds, which present a broken outcrop along the eastern boundary from Gotham to Glen Parva, forming a narrow band contiguous to the Lower Lias tract east of the Soar Valley and Rugby branch of the Midland Railway. The general trend of the beds is to the south-east. Northwards the Trias is continuous into Derbyshire, the Lower Keuper at Kegworth and Castle Donington being faced by similar beds on the north side of the River Trent at Weston, and the Red Marl stretches beyond the north and east banks of the Trent to Nottingham and Newark. The Lower Keuper and Red Marl on the west are continuous with similar tracts in Warwickshire and Staffordshire (except where faulted down), which in part form a covering mantle above continuous Coal-measure tracts except where these have thinned out, and lie in shallow basins or are cut out by subterranean ridges of igneous or Cambrian rocks.

The Leicestershire Trias is developed by several rivers which cut down to its lower beds in the west, the River Mease, south of Measham, traversing Lower Keuper country, flowing into the River Trent, the River Sence and its tributaries, rising near Bardon, flowing through Red Marl country into the River Anker, a tributary of the River Tame. The River Soar, rising near Sharnford, flows east towards the east boundary near Whetstone, then due north. The Earl Shilton, Glenfield, and Thurcaston brooks flow east into the River Soar, as consequents, south and east of the Charnian range, and north of it the Long Whatton and Garendon brooks flow east into the River Soar near Hathern and Stanford. Thus a radial arrangement of drainage systems is interwoven with an earlier system of strike and dip streams. With the exception of the older rocks forming ridges or isolated hills and the valleys formed by these rivers,, the country, save where sandstones locally make escarpments, is extremely uniform, presenting a marked contrast to East Leicestershire with the lofty escarpments of the Lias and Oolites.

Apart from the enormous denudation caused upon the east side by the agency of ice in the Ice Age, there is no doubt that not only the present but also an earlier peneplain existed, when Charnwood was doubtless bridged over by Lias, and even later rocks now removed. Unless such cover existed between Triassic and later times it is difficult to imagine how so long a period, during which they were exposed to denudation, could have elapsed without complete removal of the Trias in Central England. Moreover, in post-Carboniferous times great denudation occurred, causing inequalities in the Trias floor, and whilst one member was deposited the rest were being likewise denuded in part.

Formerly a great part of this district was covered by the Forests of Charnwood and Leicester, which extended over the entire western half of the county. Now the district is given up to pasture-land with scattered woods and parklands. The soil is sandy in the lower part, and more wooded than in the Red Marl district, which is largely given up to pasture and arable land. The Upper Keuper Sandstone forms hilly districts suitable for the growth of trees, and the soil is grey, a feature serving to distinguish its outcrops from those of the Red Marl. The Tea-green Marl outcrops also give a white soil, and the Rhætic a dark-bluish black soil easily distinguished in the field. On the latter also trees grow well.

The Upper Keuper Sandstone horizons rise to over 400 O.D. in the west, at Orton 400 O.D., 290 feet at Ratcliffe, and 220 feet at Dane Hills. A sandstone lower down at Botcheston crops out at 400 O.D. also, all more or less on high ground.

The Keuper Marl forms high ground at Hinckley, Barwell, and Burbage, south of which it is cut through by the River Soar. North of this also there is a tract 5 to 8 miles wide from Peckleton to Whitwick, where the Red Marls form higher ground, from 400 to 800 feet, than the rest of the country to the south and east, where it lies between 100 and 300 feet.

The hills in the southern part are largely due to river development, south of the River Soar striking north and south, whilst the Upper Soar Valley is free from undulations. The higher ground north of Hinckley and Bosworth is ramified by ridges running east and west, north-east and south-west, and further north by the more or less concentric ridges following the horse-shoe structure of Charnwood Forest, developed partly by modern streams, partly as a result of the ancient contour of the submerged highlands now largely filled in by Red Marl, which in places has again been excavated by the denuding forces of rain, frost, and atmospheric agencies. It is in this upper region that the most complex structure of the Red Marl area is to be met with, and where radial dip and other features play a characteristic part, largely dependent upon the contours of the ancient rocks which have contributed towards the formation of a basal breccia and scree where the two formations are superposed unconformably, as is invariably the case.

The details of the relation of the Charnian rocks to the Upper Keuper Marls and the Lower Keuper Sandstone will be discussed elsewhere.

2. Summary of Previous Work.

Leicestershire has not been wanting in scientific workers in the domain of Triassic geology. Since it occupies so large a portion of the county this would not fail to attract the attention of both local and more general geologists. The list in my bibliography of papers, etc., extends to over one hundred.

Early workers here were J. B. Jukes, who was accompanied by

Sir Roderick Murchison. George Maw paid visits. Professor Hull, in connexion with his survey work, investigated the Coal-field and outlying tracts of Trias, and was much helped by the Rev. W. H. Coleman, of Ashby. Ansted wrote on the district. The Rhætic rocks have been described by Harrison, Wilson, Browne, and others. The Lower and Upper Keuper have received some attention also. Dealing first with the former, J. Shipman, in 1882, noticed the occurrence of galena in the Lower Keuper Sandstone near Shepshed, deriving it from the outliers of Carboniferous Limestone to the north-west. More recently the footprint of a Labyrinthodont, discovered at Kegworth, was noticed in the Report of the British Association on the Flora and Fauna of the Trias by the writer, a description of which appears hereafter.

Papers upon the Upper Keuper have been more numerous. In 1850 John Plant noticed the outcrop of Upper Keuper Sandstone in the New Parks on the Leicester and Burton line, and gave certain tracks, assignable to Crustacea or Annelids, or possibly plant-remains, the name of *Gorgonia keuperi*, which he did not describe, and the name must therefore be regarded as a *nomen nudum*, and disappear, especially as there is no doubt that the fossils in question have nothing to do with Cœlenterata. In 1856 his brother, James Plant, an active local geologist, published a further description of these beds, giving a vertical section (which, however, is wrongly given as north and south, instead of west and east), and a detailed section and lists of fossils. Montagu Browne later (1893) criticizes this paper in regard to these details and as to the continuity of the Upper Keuper Sandstone, east of the River Soar. It was followed by similar accounts of the same beds in Warwickshire by the Rev. P. B. Brodie. George Maw was one of the first to notice the fact that the Charnian system is a buried mountain chain which has been covered up by the Red Marl which surrounds it, except where exposed to denudation and excavated.

The Keuper around Burton-on-Trent and parts of Leicestershire was described in a handbook on that town by W. Molyneux, who made several original observations, noticing the undulations that affect the marls, both red and green, and the existence of *Cheirotherium* footprints on the Ashby Road and near Brizlincote. J. Plant wrote a paper on the occurrence of pseudomorphs of salt crystals in the Red Marl, which in the then state of Triassic knowledge was of considerable importance. We now know they are of universal occurrence at many horizons.

Montagu Browne contributed several papers upon the Keuper around Leicester, of which that published in 1893 was the most valuable, giving more than a hundred sections with useful remarks upon the Trias in the Borough of Leicester. A very full list of fossils is given at the end of this paper also. The critical remarks show that he was well acquainted with the Trias in the field. In a later paper upon the geology of the Beaumont Leys Estate he gave the details of numerous trial-holes made to ascertain the possibility, or rather the reverse, of finding coal on that estate.

Professor W. W. Watts in 1905 published his well-known paper upon the buried landscape of Charnwood Forest, the result of several years detailed work as a geological surveyor. It gives a succinct account of the relation of the Red Marl to the older rocks so far as the stratigraphical relations are concerned.

A short but valuable paper by W. Keay and M. Gimson upon the relation of the Keuper Marl to the Pre-Cambrian rocks at Bardon Hill throws into light the enormous amount of denudation to which this deposit has been subjected, a fact reflected in the Drift deposits to the south, largely made up of Trias debris. In 1907 T. O. Bosworth wrote upon the origin of the Upper Keuper of Leicestershire, attributing it to desert agency, citing as evidence cases of wind action and other subaerial evidences when in contact with syenitic or granitic rocks. He has pursued this point further in a paper but recently published, but of which I have not seen a copy.

From 1907 to 1909 the reports upon the Trias flora and fauna have contained articles upon the Leicestershire Upper Keuper, summarizing the palæontology of this period. In 1910 the writer's views as to the origin of the Trias, i.e. as a delta formation, were promulgated, and though combated at the time appear to be receiving wider acceptance.

The Rhætic beds of Leicestershire have been described by a number of authors. The first published notice of them was by Brodie in 1874, but J. Plant indicated their probable occurrence on the Spinney Hill range in the sixties, a prophecy later fulfilled. It has been stated that Rhætic beds were found by Robert Etheridge at Barrow-on-Soar. If so he never published the fact, but in 1874 H. B. Woodward described a visit with a colleague to compare the Rhætics there with those at Newark. J. Plant also in this year referred in a report upon the Geology of Leicestershire to the occurrence of Rhætics at Leicester. It was not till 1876 that Mr. Harrison published his description with sections and lists of fossils, including *Ophiolepis damesii* and *Pholidophorus mottiana* at Spinney Hills. He assigned, as did others at that time, the Tea-green Marls to the Rhætics. Later the same beds were described by Mr. H. E. Quilter. Edward Wilson had been visiting this district, being then at Nottingham Museum, and he collaborated with the last-named in a joint description of a new section at Glen Parva, which has since been much opened up and presents one of the finest exposures in the country from the Lias to the Red Marl. Messrs. Bates & Hodges described a fresh section at Spinney Hill in 1886. Dr. A. S. Woodward examined the fossil fishes at Glen Parva, regarding them as *Ph. higginsi*, of which *Ph. nitidus* was a small form only.

From 1890 onward Montagu Browne worked hard at the local Rhætics, paying visits to Aust, Watchet, and elsewhere to obtain a wider knowledge of the formation, and established quite a reputation as an authority on the formation for twenty years or more. He found *Ceratodus* in material from Spinney Hill. When the Great Central Railway was being laid down he visited the then fine section of Rhætics at East Leake, at the suggestion of W. T. Tucker, F.G.S., of Loughborough, and obtained quite an interesting series of fossils therefrom. His last paper upon the Rhætics in 1901 summarized all previous knowledge of the Glen Parva section. This was criticized and amplified recently by Mr. L. Richardson, who asked the writer to check his new measurements, which was done with approval at the time. Since then I have had reason to examine it in greater detail with somewhat different results. Messrs. A. J. S. Cannon and Siddons have recently been examining this section systematically for fossils, and have obtained some very fine and interesting material. Some of this has been described recently, but other material will be alluded to later. The fossil annelid *Archarenicola* is of especial interest, constituting a new type.

Of works dealing generally with the geology of Leicestershire, the earliest is that of J. B. Jukes, who contributed an original and valuable memoir to Potter's *Charnwood Forest*. The Rev. W. H. Coleman, of Ashby, a friend of Professor A. H. Green, who was his pupil, wrote another good general article for White's Directory. Ansted dealt with the physical geography and geology in 1866, but very little of this work was original. *The Geology of England and Wales* in 1876 (and later editions) gives a general description. Harrison in his *Sketch*, 1877, gives a very good and largely original account, with photographic plates, and in 1882 he published his *Geology of the Counties*. An important memoir by Horace Brown on the Permian rocks of the district deals incidentally with the Trias, and is of first importance.

The meeting of the British Association here in 1907 necessitated a local handbook, and the geology was treated by my friend the late Mr. Fox-Strangways and Professor W. Watts. The articles on the palæontology and a bibliography were written by myself. In the same year an account was contributed by Mr. Fox-Strangways for the Victoria County History on the Geology.

The publications of the Geological Survey from time to time on this district deal more or less in detail with each formation. Those that refer to the Trias are Hull's memoirs (1860, 1869), A. J. Jukes-Browne (1885). Mr. Fox-Strangways gave an account of the district in 1900 (Sheet 155), 1903 (Sheet 156), 1905 (Sheet 141), and in 1907 in the descriptive memoir on the Coal-field. In 1909 Mr. Lamplugh described the district north of Melton (Sheet 142), including some parts of Leicestershire. Except in the last case these official survey accounts are lacking in those necessary field details which are so important for purposes of exact correlation.

The following account, therefore, whilst ignoring no previous observations, is more than half based upon original field work and laboratory study during a period dating from 1908, when my investigations in this direction received the aid of a grant from the Government Grant Committee. Until now I have only been able to publish interim reports, or records of isolated pieces of work connected with the investigation. This account, moreover, is a topographical report upon part of the area (Midlands) to be studied. Similar reports upon the adjoining counties are to be published from time to time, and a final report will give an account of the whole district and summarize the chief results of the research. Since the detailed petrographical work will take some time to complete, only a summary is given here.

3. Stratigraphy of the District.[1]

(1) *Castle Donington, Kegworth, Gotham, Loughborough, and Ashby District.*

This area is bounded on the north by the River Trent, on the west by the Ashby and Melbourne line, on the south by the Loughborough and Coalville line, on the east by the River Soar, except the district around Gotham, which, though in Nottinghamshire, is included as allied to the adjoining tract in Leicestershire. Both Lower and Upper Keuper (as well as Rhætics, see 5) are exposed in this area. They abut unconformably upon or lie above pre-Cambrian rocks near Thringstone, Carboniferous Limestone at Gracedieu, Breedon Cloud, Barrow Hill, and Osgathorpe, Millstone Grit at Thringstone and Castle Donington, the Coal-measures around Ashby and Cole Orton, and the Bunter at Castle Donington.

The Lower Keuper Sandstone and Marls as Waterstones are exposed in the north around Castle Donington. Here it forms a ridge which rises above the pebble beds at the north end of the Quarry Hill Plantation, along the banks of the Trent. The marls at the base are fairly thick, and are overlaid by about 80 feet of brown and yellowish evenly bedded sandstones, fine-grained and fairly hard when weathered, divided by flaggy green marl with ripple-marks. They form quite an escarpment on the north of the village. Though Mr. Harrison has stated that there is no breccia here, the basal beds are decidedly brecciated with a few pebbles also. A fault to the east has thrown down the sandstones. Quarries have been excavated in the sandstones which are used for building as at Weston. The marls afford a heavy loamy soil. Westward these beds may be traced north of Donington Park along the Trent as far as Melbourne. At the gasworks the dip was 14°, and the sandstones overlaid Millstone Grit dipping at 35°.

The Rev. A. Irving has reported the occurrence of a footprint of *Cheirotherium* at Castle Donington, but this probably refers to Weston, on the opposite side of the Trent, where they have been found recorded as *Labyrinthodon*. The sandstones here are thick-bedded, full of drusy cavities, like the Upper Keuper Sandstones. The overlying marls are flaggy and covered with ripple-markings, sun-cracks, rills, and rain-drops, as at Kegworth, where a similar footprint was found. The section shows 20 feet of white, grey, and brown sandstones, with flaggy marl partings. The sandstones are soft, but are quarried by the Midland Railway Company, who have a quarry at the junction. The joints of the rock are coated with manganese.

East of Castle Donington, as remarked, at Hemington the sandstones are let down, and Keuper lies against the sandstone scarps. On the downthrow side the height of the country is maintained by a sandstone in the Red Marl similar to that at Donington Park and Kegworth. Gypsum has also been noticed.

Eastwards the Lower Keuper Sandstone is lost sight of till it is exposed at Kegworth, where it forms the base of the hills on which the higher part of the town is built. Many exposures of these beds

[1] This is divided into five distinct areas for convenience.

have been noticed here, and the sandstone, which is pink in colour, has also been quarried to some extent. It is overlain on the north by alluvium and river-gravels, and to the west the Red Marl rises above it, a lobe near the windmill running out due east, whilst Red Marl also comes on to the south.

In recent excavations for sewers the marly beds with sandstones were exposed in the Loughborough Road during excavations for the Derwent Valley Water Board. A footprint of *Cheirotherium* was discovered here thirty years ago, in excavating at a depth of 3 feet in sandstone proved to a depth of 3 ft. 6 in., which runs out 700 feet north of the post office. The beds dip south-east. A spoil-heap of the marls and sandstones showed that they were abundantly ripple-marked, some of the ripples bifurcating with a variable distance between the crest and furrow. In the latter there were sun-cracks, which occurred also separately. Here and there rill-marks and rain-pittings occurred. A specimen showing pseudomorphs of salt crystals was obtained. The sandstones in these instances were grey and green, the marls reddish. A geode containing gypsum was found, and a quartzose pebble 5 by 3 inches.

Where the Lower Keuper Sandstones crop out beneath the Red Marl on the west from Melbourne southward they are of little extent in this area, though they spread westward for some distance. They may be traced along the line of railway, being exposed here and there, lying over the Carboniferous Limestone at Breedon Cloud. From Worthington to Thringstone they form high ground overlooking the Coal-measures around Ashby, which are faulted against them, a ridge running north-west by south-east. Between Griffy dam and Thringstone the base is a well-marked breccia, which is thicker than the overlying sandstones, being exposed in several places. The sandstones with a breccia at the base are seen at Gracedieu overlying the limestone shales.

At and around Cole Orton the beds rise above the Middle Coal-measures, as in North Staffordshire, in little hillocks, forming picturesque country. In the Leicester and Burton railway cutting at Breach Hill sandstones crop out above the coal-seams. There is some boulder-clay and sand on the higher ground here which obscures it, but it crops out in the valleys cut through by the streams.

Though the greater part of the beds above the Coal-measures around Ashby have been denuded, to the north-west there is an extensive patch of Lower Keuper Sandstone overlain by glacial clays and sands, which is here an outlier, giving rise to a well-marked feature with a noticeable scarp, except in the neighbourhood of Lount on the east, and on the north, east of Hartshorn. About Smisby and Pistern Hills[1] Drift overlies it, but at the former place white sandstones crop out with interbedded Red Marls. The beds are about 80–100 feet thick here, with red marly beds below and brown and yellow sandstones with flaggy partings. To the west of Ashby a fault brings in some Permian beds near the station in the

[1] A boring here proved Lower Keuper Sandstones and Marls, lying on Coal-measures with no intervening Bunter, which is overlapped by the former very widely.

railway cutting, where 2–3 feet of red and purple speckled sandstones overlie red and purple marl with nodules of hæmatite. East of these exposures the Red Marl forms a wide tract extending northwards to the River Trent and on the east to the River Soar, bounded on the south by the Loughborough line.

Though there is little Drift in this area except south of Diseworth and just north of Ashby the country is not very elevated. The contour-lines range between 200 and 300 feet as a general rule. Around Ashby the anticlinal of the coal-basin causes a slightly higher elevation up to 450 feet. In spite of this there is little variation in the general features of the Red Marl. Only a few disjointed exposures of stronger features caused by sandstones are revealed. As elsewhere in Leicestershire, the skerries exposed in pits and similar sections do not as a rule form any feature, except locally, as along the Midland Railway between Kegworth and Hathern, and on a smaller scale on the Great Central Railway near Loughborough. This is due to the general absence of flexures (upon which remarks are made later). Consequently, as observed by Mr. Fox-Strangways, it has not been possible to trace the several dominant skerries. The one cropping out on the Midland Railway is probably the second band, which lies 200 feet below the Tea-green Marls. The sandstone horizons traceable near the base of the formation belong to a series of three, the first of which lies 50 feet above the waterstones. That at Diseworth occurs as an inlier.

In the north-west of this area the Red Marl occurs as outliers south-east of Melbourne southwards to Worthington, forming slight eminences between the 200 and 300 contour-lines overlying the inliers of Carboniferous Limestone at Breedon Cloud and at Barrow Hill and Osgathorpe, two or three feet of Red Marl with a limestone breccia at the base irregularly bedded lying unconformably upon the limestone. About here are indications of the lowest skerry band.

The same skerry may be traced to the north, where at Donington Farm a bed of sandstone in the Red Marl can be followed northwards to Donington Park, where just east of King's Newton it strikes due west, and south of Weston it turns north and then thickens considerably, and striking north-east it thins out again, following the outcrop of the Red Marl in a sinuous course along the River Trent. At King's Mills it turns back south-east as far as the south boundary of the park, where it again, after a short distance, is to be traced north-west till it turns again to the east, then north-west, and finally can be followed in a south-east direction up to the Castle Donington road. A small quarry was opened up for building-stone near the gardens. Below this horizon the Lower Keuper Sandstone forms a marked feature. There are thus two terraces flanking the Trent, with plateau-like hills to the south. Eastward this sandstone follows an easterly course, till at Lockington Grange, where it dips to the south-west at 3°, it thickens out, forming a marked feature to Broad Hill, south-west of Kegworth, where it thins out again, and being lost in the Soar Valley is found to dip 5° due west. At Kegworth it has been quarried for mending roads, and is there 40 feet from the base of the Red Marl. In exposures in the brickyard to the south it is seen to consist of fine-grained white argillaceous sandstone about a foot thick, with greenish-blue marly beds, containing ripple-marks and pseudomorphs of salt crystals.

South-west of Kegworth the same sandstone, which is here fairly thick, is exposed in the valley of the Long Whatton brook south of Diseworth, and is an inlier, brought to the surface by the cutting back of the Red Marl and possibly as a result of some fold in the Red Marl which has brought it up to a higher level. A flexure is noticeable in its outcrop near Lockington Grange which may be connected with this.

East of the River Soar the Red Marl forms high ground east of the Soar Valley. From Red Hill on the Midland Railway to Thrumpton gypsum crops out continuously, and is found at the base of the two outliers of Rhætics and Lower Lias north of West Leake and about Gotham. At the last place the gypsum beds form an important feature and are worked by tunnels driven into the sides of the hills. They are generally continuous, but are dissolved in places by water which accumulates at this horizon, and marl fills the intervening spaces and is left as pillars in the workings. The Tea-green Marls crop out at Winking Hill close to the road at the south end of the northern outlier.

At the Gotham Plaster Company's works the gypsum[1] is 8 feet thick, sound and clear white, and is overlain by Red Marl, but a little grey or green marl is mixed with the less pure parts. The gallery is driven in a southerly direction for half a mile. It is ground for plaster here, as at the other pits in this district. At Shepherd's Pit to the north a similar tunnel is driven for half a mile into the hill. The gypsum is more or less horizontal, and is 8 feet thick, thinning out in places and becoming useless, as at Thurmaston.

At West Leake the Red Marl forms an outlier as in the north. To the west it is covered by river-gravels, and forms low ground, to the east by lacustrine clay at Gotham Moor, beneath which the gypsum crops out. Except along the escarpment, where sections have been cut for gypsum, there are few exposures. At Sharpley Hill the gypsum is at a lower level,[2] that at Gotham being below the Newark gypsum beds also. The Tea-green Marls crop out in the Great Central Railway at Crow Wood, and are seen again in the cuttings at White Hill, East Leake.

There is a pit west of Hutchley's Mills which shows 41 ft. 4 in. of Red Marl with two bands of ball gypsum 8 inches thick and green marl 5 feet thick as at Gipsy Lane, just below Tea-green Marls. There is no exposure at Hutchley's Mills, but the gypsum is worked by a tunnel driven more or less east into the hill. The track descends at first abruptly, but the workings, which continue for nearly half a mile into the hillside, are ultimately horizontal. The gypsum is similar to the ball gypsum of Knighton, and is ground for plaster. Pseudomorphs of salt crystals occur on the green marl.

The band of skerry which may be traced along the east side of the Midland Railway for a long distance is higher up than the Kegworth

[1] It is practically pure alabaster.

[2] 180 feet below the Rhætics at East Leake.

Beds, and is the same as a bed seen in the brickyard at Hathern. The bed exposed in the cutting of the Great Central Railway to the east is probably on a higher horizon and may represent the Dane Hill Sandstone in an attenuated form. In the brickyard there is a section 63 ft. 7 in. of red and green and white marl with two thick skerries and thinner green bands, with ripple-marks.

A boring in the brickyard passed through 48 feet (dug well), Red Marl 228 feet, sandstone and marl 126 feet, and ended in Forest rocks. In a second boring south of the village, below 110 feet Red Marl and 140 feet Lower Keuper Sandstone, 256 ft. 4½ in. Bunter and 362 feet of Carboniferous Limestone Shales and Millstone Grit were met with.

In regard to the Bunter limits, Fox-Strangways considered "they were not deposited much to the east of a line drawn through Castle Donington and Ashby, though the boring at Hathern shows that they were abnormally thick in what is now the valley of the Soar". De Rance remarks, "The eastern boundary of the outcrop of the Pebble Beds of the Bunter ranges along the River Trent, past Nottingham, as far as Stanton and Swarkeston. Eastward of this line the Keuper Sandstone rests on the Coal-measures of Ashby-de-la-Zouch and the Carboniferous Limestone of Breedon Hill. Ranging parallel to this line and eastward of it, the Lower Keuper Sandstone building stones and conglomerate thin out, being last met with at Hathern, ranging north of Charnwood and Atherstone. South of Nuneaton fine-grained white sandstone used for building occurs, interbedded with evenly bedded shale of the waterstones."

Horace Brown remarks that the Permian too, in Leicestershire, is not met with east of Packington. There is thus abundant evidence that the Trias deposits overlap each other in all directions, the newer divisions transgressing upon older rocks beyond the area of the newer divisions, indicating a considerable subsidence during this period. Whilst the Lower Keuper is slightly thicker in some directions to the south-east it attains its maximum at Hathern, and though there is a south-easterly attenuation of the Trias generally around the older rocks there is, especially in this area, a thickening of the deposits eastward, borings at Leicester showing a thickness of over 600 feet.

The borings at Piper Wood, north of Shepshed, are difficult to correlate, but there appears to be here, as at Hathern, underlying the Red Marl a considerable thickness of Millstone Grit, and possibly Carboniferous Limestone Shales. Taken with the outcrop of Millstone Grit at Castle Donington, it would seem that there is an anticlinal of the Carboniferous rocks, perhaps, related to an older anticlinal of Charnian rocks running north-west by south-east, and to this we may attribute such evidence as there is of flexures in the Red Marl, forming the Diseworth inlier. This was produced in post-Triassic times along a fold which had previously, and has since, been subjected to renewed activity. Between here and Loughborough much more drift obscures the Red Marl, and exposures are few. Here the Red Marl is thicker and dips south-east at a low angle. In a few brick-yards in the town the marls are used for brick- and tile-making, but are usually covered by alluvium and river-gravels. So that sections made during the construction of the Great Central Railway and in the town have revealed nothing of importance. From Normanton Hills southward the section is in Red Marl, up to the Soar Valley, just opposite the Loughborough Road. In a cutting a bed of sandstone 3 feet thick, dipping to the north at 1°–2°, was encountered. At Nottingham Road the marl was 8 feet thick, at the Midland Railway 14 feet, and at the Canal 12 feet.

Turning to the surrounding area, it may be noted that the gypsum at Chellaston where alabaster is obtained is 6 to 12 feet thick. The Red Marl forms a feature, and in the overlying Drift Foraminifera were obtained, once thought to be Triassic.

At Chilwell,[1] to the north, a thick band of sandstone near the base is brought up on the south side of a fault, and is 20 to 30 feet thick, and resembles the Dane Hill Sandstone. A band of skerry near the base of the marl here is traceable from Derby to the Erewash Valley. In the Sandstone salt pseudomorphs are abundant.

A boring at Clifton Colliery showed 157 feet of Red Marl overlying the Coal-measures. At Ruddington there was 386 feet of Red Marl, 75 feet Waterstones, 218 feet Bunter, above Coal-measures dipping at a high angle. At Owthorpe there was 12 ft. 6 in. Lias, 34 ft. 6 in. Rhætics, 633 feet Red Marl, 125 feet Lower Keuper, 428 feet Bunter, overlying Coal-measures.

At Melton Mowbray the section was—

	Feet.
Loam and gravel	14
Boulder-clay	24
Lower Lias	230
Rhætic	16·4
Upper Keuper (Tea-green, 24 feet)	248
	532·4

This shows that while in Leicestershire the Bunter thins out eastward, northwards there are deep hollows in these beds, and that they thicken eastward locally, thinning southward. The Lower Keuper also thickens eastward, but to a less extent.

(To be continued in our next Number.)

REVIEWS.

I.—Development and Systematic Position of the Monticuliporoids. By E. R. Cumings. Bulletin of the Geological Society of America, vol. xxiii, pp. 357–70, pls. xix–xxii, 1912.

The systematic position of the Monticuliporoids has long been uncertain. Considered by Nicholson as 'Tabulate' Corals, they were generally so regarded. Ulrich, and after him Bassler, American specialists in Palæozoic Polyzoa, claimed them for their group; and

[1] A boring here passed through Red Marl and Sandstone 167 feet, Pebble Beds 258 feet, Soft Sandstone 33 feet, and 877 feet of Coal-measures.

palæontologists nowadays place them, usually with some hesitation, among the Polyzoa. Eastman in his translation of Zittel's *Grundzüge der Paläontologie* takes the original course of placing them under both Corals and Polyzoa. Still more startled were palæontologists when a letter written by Kirkpatrick to *Nature* appeared,[1] stating that Monticuliporoids were allied to *Merlia*, a recent siliceous Sponge. "The discovery," says Kirkpatrick, "of the solution of the problem of Merlia is destined to prove of profound importance to palæontologists. For I have now convincing proofs . . . that numerous Palæozoic fossils coming under the old-fashioned term 'Monticulipora' are essentially the same nature as Merlia, and that they are supplementary calcareous skeletons of siliceous sponges. Merlia seems to be a solitary survivor of the Monticulipora type from Palæozoic times . . ."

Now it was obvious that, if *Merlia* were a siliceous Sponge and the Monticuliporoids allied to it, the post-embryonic development would be similar in both cases, whereas if Monticuliporoids were Polyzoa they should present post-embryonic stages characteristic of that phylum. What was required, then, was the determination of the early stages of Monticuliporoids. This was meanwhile being done, quite independently of any thought of *Merlia*, by Cumings in America, with the result that, in the same month as Kirkpatrick's letter in *Nature* appeared, there was published an account by Cumings of the early stages of certain Monticuliporoids, showing them to agree closely in this direction with Cyclostome Polyzoa.

The genera in which Cumings has shown Polyzoan growth-stages from the time when the larva first became fixed are three—*Prasopora*, *Phylloporina*, and *Callopora*; but in four other genera he has found very early, though not the earliest, stages, which leave no doubt that these four genera are of the same nature as the first three. It is unfortunate that Cumings makes no mention of the earliest stages of *Monticulipora mammulata*, the genotype of *Monticulipora* chosen by Nicholson[2] from the four genosyntypes presented by d'Orbigny.[3] For it is possible, though unlikely, that included among the Monticuliporoids are forms not related to the Polyzoa; and it is the genotype of *Monticulipora* that Kirkpatrick claims as related to *Merlia*. Now, should this prove to be anything but a Polyzoan, the name Monticuliporoid, used, apparently, by Cumings as synonymous with Trepostome, will have to be abandoned to whatever group includes *Monticulipora mammulata*.

If, as is likely, *Monticulipora mammulata* is proved to be symphyletic with the genera that Cumings has conclusively shown to be Trepostomes, it presents in its skeleton a very pretty example of homœomorphy with *Merlia*.

It is important to appreciate the nature of Cumings' evidence. Four Polyzoan orders are well known as fossils, namely, Cyclostomata, Trepostomata (including Monticuliporoids), Cryptostomata, and

[1] *Nature*, vol. lxxxix, p. 502, 1912.

[2] Nicholson, *On the Structure and Affinities of the genus Monticulipora and its sub-genera*, 1881, p. 1.

[3] D'Orbigny, *Prodrome de Paléontologie stratigraphique universelle*, vol. i, p. 25, 1850.

Cheilostomata; and of these the last three may be derived each independently from the first. It is to the Cyclostomes, then, that we look for the primitive and typical development. Barrois[1] and Harmer[2] have each worked out in detail the development of *Tubulipora*, a recent Cyclostome of primitive standing. But, as far as the skeleton is concerned, the earliest stages can be studied with ease in the still more primitive Stomatoporas well preserved as fossils in British Jurassic rocks.[3] On settling, the Polyzoan larva secretes a shell of spherical shape—the protœcium,[4] from which springs the first individual—the ancestrula.[5] In the most primitive forms (*Stomatopora*) the ancestrula gives rise to one or two buds; in the more advanced though still primitive forms (*Berenicea*, *Tubulipora*) three buds spring from the ancestrula, and these in turn give rise to a varying number. In *Berenicea* and other discoid forms the later buds curl round and may cover the protœcium and often the ancestrula too; and this tendency has caused difficulty in demonstrating the protœcium in certain Palæozoic forms. Generally speaking, then, the typical early stages of the Cyclostome appear as an ancestrula with a bulbous proximal end (the protœcium) and with one, two, or three distal buds. The Cryptostomata show similar stages before taking on characters peculiar to themselves.[6] In the Cheilostomata development is condensed by tachygenesis, in accordance with their specialization, to such an extent that the protœcium is merged in the ancestrula,[7] which itself has already lost the primitive tubular form. Among the Trepostomata Cumings has now demonstrated the globular protœcium and ancestrula with three distal buds in *Prasopora*, *Callopora*, and *Phylloporina*, and the post-protœcial stages in *Peronopora*, *Rhombotrypa*, *Amplexopora*, and *Homotrypa*; in *Rhombotrypa* and *Amplexopora*, however, the ancestrula apparently gives rise to two buds only.

It is now possible to form some idea of the inter-relationship of the four Orders. The Cyclostomes undoubtedly are the most primitive, since they alone show the complete demarcation between the protœcium and ancestrula—the two appear as separate entities. The Trepostomes show early stages exactly comparable with Cyclostomes, except that the demarcation between protœcium and ancestrula is hardly to be seen, the latter appearing as the distal end of the former. The characters separating Trepostomes from Cyclostomes concern the characteristic habit of growth, the nature of secondary skeleton, and matters of heteromorphism; but the tubular zoœcium and simple

[1] Barrois, *Recherches sur l'embryologie des Bryozoaires*, 1877, pp. 70–85, pls. iii and iv.

[2] Harmer, "On the Development of *Tubulipora*": Quart. Journ. Micros. Sci., vol. xli, pp. 73–157, 1898.

[3] Lang, "The Jurassic forms of the 'genera' *Stomatopora* and *Proboscina*": Geol. Mag., Dec. V, Vol. I, pp. 315–22, 1904.

[4] Cumings, "Development of some Palæozoic Bryozoa": Amer. Journ. Sci., ser. IV, vol. xvii, p. 50, 1904.

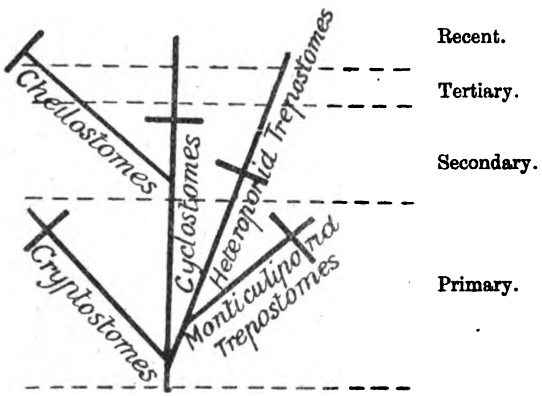
[5] Jullien, *Mission Scientifique du Cap Horn*, *1882–3*, tom. vi, Zoologie—Bryozoaires, p. 29, 1888.

[6] Cumings, op. cit., pp. 58–74, 1904.

[7] Cumings, "Development of *Fenestella*": Amer. Journ. Sci., ser. IV, vol. xx, p. 170, 1905.

aperture are retained by both. Their ranges are conterminous, though the Trepostomes reached their maximum in the Palæozoic, are rare in Secondary rocks, and hardly ever found in Tertiary and Recent times.[1] The Cyclostomes, on the contrary, reached their maximum in Cretaceous times and are very abundant now. Cumings' view is that "the two orders are cognate and do not stand in linear relation one to the other". This can mean only that when a common ancestor is reached, Cumings would consider it neither a Trepostome nor a Cyclostome. I should rather regard it as a Cyclostome, and say that the Trepostomes branched from the Cyclostome stock at a very early date.

In their earlier stages the Cryptostomes resemble the last two orders, but there is a greater condensation of the protœcium and the ancestrula—the latter appearing merely as a distal appendage of the former.[2] They may be, therefore, an independent offshoot of the Cyclostomes, as Cumings regards them,[3] or a side branch of the Trepostome stock soon after these had diverged from the Cyclostomes. Cryptostomes are confined to the Palæozoic.



Cumings is inclined to regard the Cryptostomes as 'Palæozoic representatives' of the Cheilostomes,[3] that is to say, presumably that, with their modified apertures, they fill the same bionomic role alongside the Cyclostomes as do the Cheilostomes at the present day, and not that the Cheilostomes are their linear descendants. The earliest stages of those Cheilostomes in which these have been investigated show the protœcium completely merged in the ancestrula—they become identical. Except for the isolated record and figure by Lamouroux[4] of *Onychocella* from the Jurassic Calcaire à Polypiers of

[1] What are here considered as the post-Palæozoic Trepostomes are the Heteroporidæ, Cerioporidæ, and their allies.

[2] Cumings, loc. cit., 1905.

[3] Cumings, op. cit., p. 76, 1904.

[4] Lamouroux, *Exposition Méthodique des genres de l'ordre Polypiers*, 1821, p. 113. The three specimens mentioned in the British Museum Catalogue of Jurassic Bryozoa, 1896, as coming from the Norman Calcaire à Polypiers are not free from doubt; one certainly and another probably are from the Cretaceous of Maastricht.

Normandy, the first Cheilostomes are found in the Cretaceous and never are abundant until the Cenomanian; they are at their maximum to-day. It is probable that they too had an independent origin from the Cyclostomata. The diagram on p. 35 suggests these relationships; the divergence of the lines from the normal represents a corresponding degree of specialization; and the transverse lines show the point at which the group reached its maximum.

I have attempted in this review to bring Cuming's paper into relation with the general question of Polyzoan relationship and to demonstrate its importance to the subject at large. It appears to be a distinct forward step, and in its far-reaching results has a right to be considered a very marked success of the onto- or rather in this case the asto-genetic method.

W. D. Lang.

II.—The Work of Rain and Rivers. By T. G. Bonney, Sc.D., LL.D., F.R.S. 8vo; 144 pages, with 19 text-illustrations. Cambridge: at the University Press, 1912. Price 1*s*. net.

THE aims of the Cambridge Manuals of Science and Literature are by now become fairly widely known, and the present volume is likely to be successful in rendering available to persons of ordinary education a digest of observations made during many years by the "veteran tourist", Professor Bonney. As the author tells us, the volume is not calculated to contain new information, but his authority and experience, it may be added, are a sufficient guarantee that nothing of essential importance has been omitted. Four chapters are devoted to the subject of "Rain and Rivers", and a fifth is a résumé of the history of "Man's Learning of Nature's Lesson".

In "Carving and Carrying", as the first chapter is termed, we find reference to the familiar 'pipes' in the Chalk and to operations of meteoric agents on a small scale, such as may commonly be seen in all parts of England. For many of his illustrative examples, however, the author takes us farther afield, and not unnaturally makes frequent reference to the Alps.[1] It is possible, indeed, that the detailed descriptions of some not generally well-known districts may fail to commend themselves to the ordinary reader. In the case of a more complicated topic like the history of a river-system it is an advantage, as the author points out, to discuss foreign examples first, because their history is "written in bolder characters and in plainer terms. . ." The chapter on the making of valleys is a very clear exposition, and contains a large amount of information. The following one, on transport and deposit, furnishes various statistics of interest.

The last chapter traces the history of "Man's Learning of Nature's Lesson" from the times of Herodotus and Strabo through those of Hutton and Playfair to the present day. In animadverting on the work published in 1857 by Colonel George Greenwood (the "father of modern sub-aerialism" as Mackintosh styled him), Professor

[1] [See review of Professor Bonney's latest book, *The Building of the Alps*, Geol. Mag., December, 1912, pp. 564–6.—Ed.]

Bonney quotes somewhat discursively from contemporary opinion—not always a safe criterion. It is unfortunate that the author should not have observed the additional testimony of the review from which he gives an excerpt that this earlier writer "must be credited with the merit of having been the first of late years to give to the world . . . a clear exposition of the sub-aerial theory of denudation".[1]

The illustrations are limited to nineteen in number, and, it must be confessed, afford scope for improvement; but of the text of this book it may unhesitatingly be predicated that it will help its readers "to understand better and regard with deeper interest" the earth on which they live.

III.—A Textbook of Palæozoology.

Lehrbuch der Paläozoologie. By Professor E. Stomer von Reichenbach. Erster Teil: Wirbellose Tiere, pp. x, 342, with 398 figures (1909). Zweiter Teil: Wirbeltiere, pp. viii, 325, with 234 figures (1912). Leipzig: B. G. Teubner. Price 10 marks each volume, cloth.

THIS textbook differs from the majority of recent palæontological textbooks in that it does not, as a rule, give diagnoses of genera, but usually confines itself to orders and higher divisions. It has the advantage of being much more readable, but the drawback is that it cannot be used for determining genera. In the first volume, after an introduction of twenty-eight pages dealing with the condition and preservation of fossils, the skeleton, etc., the Invertebrata are described. After the description of each phylum, sub-phylum, or class, a short diagnosis of its subdivisions, a graphic table of their distribution in time, a section on their geological occurrence and evolution and a bibliography are given. In the second volume, after an introduction of thirteen pages, the Vertebrata are similarly treated.

At the end of the second volume sixty-three pages are devoted to concluding remarks on the succession of faunas, the geographical distribution and œcology of animals in the geologic past, palæozoology and the theory of evolution, death and extinction, and the literature of these subjects. Considered as a whole the work is much more attractively written than most German textbooks. It is very well printed and both volumes are excellently illustrated with a great number of recently described fossils, and there is a good index to each.

B. Hobson.

IV.—The Structure of the Earth.

By T. G. Bonney, Sc.D., F.R.S. 8vo; pp. 1–94. London: T. C. & E. C. Jack, 1912. Price 6*d.* net.

POPULAR exposition of geological science is now receiving due attention, and it is fortunate that such an experienced teacher as Professor Bonney should have undertaken to write this small volume for "The People's Books" series. The subject is introduced

[1] Geol. Mag., 1867, p. 412.

by a consideration of the problems and methods of geology, and the attention of the lay reader is at once engaged by the mention of familiar geological phenomena. The author then proceeds to discuss the constitution and age of the earth. He gives a clear idea of the relations in size and distance of various members of the solar system, but, very wisely perhaps, refrains from discussing the origin of our planetary system, commencing his story with the earth as a glowing mass. We then see the origin and nature of the present crust of the earth. The various agencies that have affected its configuration—heat and cold, running water, snow, ice, and the sea—are interestingly considered, and a short chapter is devoted to a very clear account of volcanoes. The occurrence of marine fossils at great heights on the earth's surface, among other phenomena, is then referred to in proof of the changes that have taken place in land and sea; and finally we have a review of the succession of life on the earth. Additional value is given to this work by the inclusion of a well-arranged bibliography.

V.—Dana's Manual of Mineralogy. Thirteenth Edition, entirely revised and rewritten by William E. Ford. 12mo; pp. viii, 460, with 10 plates. New York, John Wiley and Sons; London, Chapman & Hall, 1912. Price 8*s*. 6*d*.

THE revision of this well-known manual will be very welcome, for although the book has been frequently reprinted it is twenty-five years since the text was revised. The present volume is arranged on the same plan as formerly, but there are some necessary omissions and not a few useful additions. Thus we find that the chapter on petrology has been excluded, but there is a useful account of the occurrence and association of minerals. There is less detail in the descriptive portion of the book, and the catalogue of American localities is omitted—changes that will be quite in keeping with the requirements of the general student. As new features we note the useful list of minerals arranged according to systems of crystallization, and the statistics of mineral production in the United States for 1910. The tables for the determination of 203 species are decidedly useful in their new form, and the ten photographic plates make a good addition. The book is well printed, contains 357 text-figures, and has a convenient index; printers' errors are rare, although we observe a misspelling of 'cryptocrystalline' on p. 176. We now have several excellent elementary manuals of mineralogy, but the present volume will take a high place in making the Dana series complete.

VI.—Brief Notices.

1.—The Beginner's Guide to the Microscope. By Chas. E. Heath, F.R.M.S. 8vo; pp. 1–119, with 46 text-illustrations. London: Percival Marshall & Co., n.d. Price 1*s*. net.

THERE is no pretence in this little book of giving instruction in scientific microscopy: its aim is purely to teach the beginner to use the instrument as a means of recreation. As an introduction to the essentials of a modern microscope, however, it should prove of distinct use. The various parts of the instrument and their uses are described, and the subject of illumination is well dealt with. The hints given regarding the choice of a microscope are likely to be of value to the class of readers for whom the book is intended, and the same may be said with respect to the instruction given on the mounting of objects. To readers taking up the study of petrology, however, the book could scarcely be recommended as comprehensive. An account of the camera lucida would not have been out of place.

2.—The Origin and Evolution of Primitive Man. By Albert Churchward, M.D., F.G.S. Crown 8vo; pp. 88, pls. 46. London: George Allen & Co., Ltd., 1912. Price 5s.

THIS is a discursive little book specially devoted to pointing out the so-called mistakes of 'authorities'. The writer asserts that "it was in Africa that the little pygmy was first evolved from the *Pithecanthropus erectus* or an Anthropoid Ape", and then gives some account of the African pygmies as the survivors of the earliest type of man. He thinks that the skeleton lately discovered near Ipswich is probably that of a Nilotic negro, though he "cannot positively say if this was a man of late exodus of the Nilotic negro, or one of an early exodus of Stellar Mythos". Notwithstanding the beautiful photographs of implements and primitive peoples with which the book is illustrated, we fear it will scarcely commend itself to geologists.

3. Geology of Egypt.—Attention was called (Geol. Mag., 1910, p. 571) to the issue of two colour-printed geological maps of Egypt, by the Survey Department, Cairo; one on a fairly large scale in six sheets and the other in one sheet. The Department has now (1912) issued *Explanatory Notes to accompany the Geological Map of Egypt, with tables showing distribution of geological formations and economic products.* The work is written by the Director of the Geological Survey, Dr. W. F. Hume, and it contains a concise account of the geological features and history of the formations, illustrated by two plates of longitudinal and vertical sections. As a guide in the field, and for reference, this thin volume will be of great utility.

4. Croydon Natural History and Scientific Society.—The Proceedings and Transactions of this Society for the session 1911–12 contain the Address of the (now past) President, Mr. W. Whitaker, F.R.S., entitled "Surrey Geology in the past Eleven Years". In this is given an exceedingly useful record of the works published (with comments), thus continuing the record of subjects dealt with in the previous geological addresses (1900–1) by the same President. Dr. H. Franklin Parsons, F.G.S., was elected President for the session 1912–13. He has contributed to the volume an important paper on "The Flora of the Commons near Croydon", with notes on the physical features and geology of the several areas.

REPORTS AND PROCEEDINGS.

I.—The Cambridge Philosophical Society.

On a remarkable instance of complete Rock Disintegration by Weathering. Abstract of a paper read by Dr. F. H. Hatch before the Cambridge Philosophical Society on November 25, 1912.

THE material described comes from Diamantina, in the province of Minas Geraes, Brazil, where it is being worked for diamonds. It occurs as a loose sandy deposit in which there are a number of partially disintegrated pebbles, and is sufficiently soft to be dug out with the shovel at the lowest depth yet attained in the open-working.

The pebbles consist of quartzite, vein-quartz, steatite, and tourmaline-quartz vein-stuff. The sand is a mixture of colourless quartz and of the fine powder produced by the pulverization of the steatite fragments. The heavy minerals in the residue obtained by treatment with bromoform, are the following: zircon, zinc blende, galena, iron pyrites, chalcopyrite, rutile, and tourmaline.

The material has evidently resulted from the prolonged weathering of an ancient conglomerate formation. The weathering agents have not only removed the cement of the conglomerate, but have also abstracted the material that originally cemented the constituents of the quartzite pebbles, which have consequently been reduced to a friable condition, and can even be crushed to powder between the fingers.

The diamonds, which occur in the following forms—octahedron, rhombic dodecahedron, three-faced octahedron, and six-faced octahedron, have a characteristic greenish tint, seen under the microscope to be due to the presence of small spots and flecks of some chloritic mineral. It is, however, only 'skin-deep', the cut stones being perfectly clear and colourless.

II.—Geological Society of London.

November 20, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Hafslo Lake and the Solvorn Valley (Norway)." By Horace Woollaston Monckton, Treas.L.S., F.G.S.

The district dealt with lies north of the main Sogne Fjord and west of the Lyster Fjord. Attention is drawn to a series of valleys running from the area of the Jostedal snowfield and cutting the belt of Silurian rocks which crosses the district in a north-easterly and south-westerly direction, and to a second series of valleys which run parallel to the snowfield and to the Silurian belt. The author traces the valley of the Vejtestrands Lake, which belongs to the first of the above series, until it reaches the Hafslo Lake, which lies at a point where the valleys of the two series intersect. The present line of drainage follows a valley of the second series from the lake to the fjord, but a disused outlet from the lake to the fjord is described belonging to the first series. The author, while thinking that the disused outlet is probably the older of the two, gives reasons for believing that both outlets were in use perhaps simultaneously during the latter part of the Glacial Period, when a glacier filled and overflowed the basin of the Hafslo Lake.

The author describes some giants' kettles and other examples of erosion by water, which for various reasons he believes to date from a time when the glacier extended to the places where they are now found, and it is suggested that they were the work of a river flowing under the ice or between the ice and the rock.

2. "On the genus *Aulophyllum*." By Stanley Smith, B.A., M.Sc., F.G.S., Clare College, Cambridge.

Aulophyllum is a genus belonging to the Clisiophyllid group. It is found in the Upper Beds of the Carboniferous Limestone Series in Britain and on the Continent. It appears in the lower part of the *Dibunophyllum* zone (D_1), becomes common in the middle subdivision of the zone (D_2), and is plentiful in the highest limestones investigated (D_3).

The coral was first described by David Ure, in 1793, as *Fungites*; the genus was established by Milne-Edwards & Haime in 1850. The author includes in this genus Thomson's genus *Cyclophyllum*. The genus is described in detail, and then the ontogenesis is discussed. The development of the various items of coral anatomy is first treated; and the author subsequently deals with the growth of the coral considered as a whole, six stages being recognized by him. The forms found in D_1 do not advance beyond stage *d*.

Structural variation is then considered. The author regards all the species previously described as variations of the same species, but recognizes several well-marked types and a number of time mutations. Many specimens of the coral display the phenomenon of rejuvenescence. The structural changes observed are described, and the nature of the rejuvenescence is briefly discussed.

December 4, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Lower Palæozoic Rocks of the Cautley District (Yorkshire)." By John Edward Marr, Sc.D., F.R.S., V.P.G.S.

The following classification is suggested for the Ordovician rocks of the district:—

ASHGILLIAN.	Ashgill Shales.	
	Beds above the Volcanic Group.	*Staurocephalus* Beds.
	Contemporaneous Volcanic Group.	*Staurocephalus* Beds.
	Beds below the Volcanic Group.	*Staurocephalus* Beds.
	Phacops robertsi Beds.	
CARADOCIAN.	*Calymene* Beds.	

The *Phacops* and *Calymene* Beds are remarkably similar in lithological characters (dark calcareous shales and impure limestones), but the palæontological change is at the top of the *Calymene* Beds, and the fauna of the *Phacops* Beds is allied to that of the succeeding strata.

In addition to other fossils, the Ashgillian strata contain graptolites, which have not been found, however, in the Ashgill Shales. *Dicellograptus anceps*, Nich., comes in the *Phacops* Beds, and ranges up into the beds above the Volcanic Group. The Ashgillian beds are, therefore, the zone of *Dicellograptus anceps*.

The succession in this district is much clearer than in the Lake District, and it is suggested that it be adopted as the type sequence for the Ashgillian beds of the North of England.

Some notes on the faunas of the Silurian rocks, of which the detailed sequence has been previously established, are given.

2. "The Trilobite Fauna of the Comley Breccia Bed (Shropshire)." By Edgar Sterling Cobbold, F.G.S.

The author describes a trilobitic fauna from the matrix of a breccia of Middle Cambrian age, found near Comley Brook, in one of the excavations made for the Excavations Committee of the British Association. This fauna includes forms referred to *Agraulos* cf. *quadrangularis*, Whitfield, *Conocoryphe æqualis*, Linnarsson, *C. bufo*, Hicks, *C. impressa*, Linnarsson, *Microdiscus punctatus*, Salter, together with new species of *Paradoxides*, *Dorypyge*, *Ptychoparia* (*Liostracus*), and some indeterminate forms, provisionally referred to *Agraulos* (*Strenuella*).

This breccia bed is made up of the recompacted waste of Lower Cambrian sandstones, many of the included blocks yielding species belonging to the *Protolenus Callavia* fauna. It rests directly upon bedded Lower Cambrian sandstone, and is therefore regarded as a basal deposit of the Middle Cambrian.

The fossils contained in the matrix indicate an horizon that is probably equivalent to a part of the *Paradoxides tessini* zone of Scandinavia. As they are specifically distinct from those of the Quarry Ridge Grits of Comley, which are also basal but rest upon Lower Cambrian limestones containing the *Protolenus Callavia* fauna, the inference is drawn that the two deposits are separated by a distinct interval of Cambrian time.

3. "Two Species of *Paradoxides* from Neve's Castle (Shropshire)." By Edgar Sterling Cobbold, F.G.S.

The author figures portions of two species of *Paradoxides*, collected in 1892 by Mr. J. Rhodes for H.M. Geological Survey. These are referred to *P. hicksi*, Salter, and to a new variety of *P. bohemicus*, Bœck.

Species of *Agnostus*, *Ptychoparia* (*Liostracus*), *Agraulos*, *Hyolithus*, and *Acrotreta* occur in the same rock-fragments, but are not sufficiently well-preserved for exact specific determination.

December 18, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communication was read:—

"On the Discovery of a Palæolithic Human Skull and Mandible in a Flint-bearing Gravel overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex)." By Charles Dawson, F.S.A., F.G.S., and Arthur Smith Woodward, LL.D., F.R.S., Sec.G.S.

The gravel in which the discovery was made occurs in a field near Piltdown Common, in the parish of Fletching (Sussex), and is described by the first author. In the section exposed it is about 4 feet thick. It consists, for the greater part, of waterworn fragments of Wealden ironstone and sandstone, with occasional pebbles of chert, probably from the Greensand, and a considerable proportion of Chalk flints, which are also waterworn, all deeply stained with oxide of iron, and most of them tabular in shape. The human skull was originally found by workmen, broken up by them, and most of the pieces thrown away on the spot. As many fragments as possible were recovered by the authors, and half of a human mandible was also obtained by the first author from a patch of undisturbed gravel close to the place where the skull occurred. Two broken pieces of the molar of a Pliocene type of elephant and a much-rolled cusp of a molar of *Mastodon* were also found, besides teeth of *Hippopotamus*, *Castor*, and *Equus*, and a fragment of an antler of *Cervus elaphus*. Like the human skull and mandible, all these fossils are well mineralized with oxide of iron. Many of the waterworn iron-stained flints closely resemble the 'eoliths' from the North Downs near Ightham. Mingled with them were found a few Palæolithic implements of the characteristic Chellean type. The gravel at Piltdown rests upon a plateau 80 feet above the River Ouse, and at a distance of less than a mile to the north of the existing stream. It appears to cover several acres, but at the same level on the opposite (south) side of the river it is represented only by scattered flints. Numerous iron-stained tabular flints, like those of the Piltdown gravel, have been found in the basin of the Ouse between the Chalk escarpment and Sheffield Park and between this escarpment and Uckfield. As they are identical with the flints well known in the plateau deposits of the North and South Downs, it may be assumed that they have been derived from a plane formerly existing between those two points.

The human skull and mandible and the associated fossils are described by the second author. The skull (which unfortunately lacks the bones of the face) exhibits all the essential features of the genus *Homo*, with a brain capacity of not less than 1,070 c.c., but possibly a little more. It measures about 190 mm. in length from the glabella to the inion, by 150 mm. in width at the widest part of the parietal region; and the bones are remarkably thick, the average thickness of the frontals and parietals being 10 mm., while an exceptional thickness of 12 mm. is reached at one corner. The forehead is steeper than that of the Neanderthal type, with only a feeble brow-ridge; and the conformation of the occipital bone shows that the tentorium over the cerebellum is on the level of the external occipital protuberance, as in modern man. Seen from behind the skull is remarkably low and broad, and the mastoid processes are relatively small. The right mandibular ramus is nearly complete to the middle of the symphysis, lacking only the articular condyle and the upper part of the bone in advance of the molars. The horizontal ramus is slender, and so far as preserved resembles in shape that of a young chimpanzee (*Anthropopithecus niger*). The lower symphysial border is not thickened and rounded, as in man, but produced into a thin inwardly curved flange, as in the apes.

The ascending ramus is comparatively wide, with extensive insertions for the temporal and masseter muscles, and a very slight sigmoid notch above. Molars 1 and 2, which occur in their sockets, are typically human, though they are comparatively large and narrow, each bearing a fifth cusp. The socket of molar 3 indicates an equally large tooth, placed well within the ascending ramus of the jaw. The two molars have been worn perfectly flat by mastication, a circumstance suggesting that the canines resembled those of man in not projecting sensibly above the level of the other teeth. The weakness of the mandible, the slight prominence of the brow-ridges, the small backward extent of the origin of the temporal muscles, and the reduction of the mastoid processes, suggest that the specimen belongs to a female individual, and it may be regarded as representing a hitherto unknown genus and species, for which a new name is proposed.

The authors conclude that the Piltdown Gravel Bed is of the same age as the contained Chellean implements, which are not so much waterworn as most of the associated flints. The rolled fragments of molars of the Pliocene elephant and *Mastodon* are considered to have been derived with the flints from older gravels; while the other mammalian remains and the human skull and mandible, which cannot have been transported far by water, must be assigned to the period of the deposition of the gravel bed itself. The remoteness of that period is indicated by the subsequent deepening of the valley of the Ouse to the amount of 80 feet.

III.—Mineralogical Society.

Anniversary Meeting, November 12, 1912.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

Professor W. J. Lewis: Ilmenite from the Lengenbach Quarry. Embedded in the dolomite was found a minute crystal, irregular in habit, showing the forms 110, $10\bar{1}$, 100, $11\bar{2}$, $11\bar{1}$, 275. The best readings were obtained from pairs of faces of 101 and between them and faces of a prism, the corresponding angles being found to be 64° 47′ and 57° 33′ respectively.—Professor W. J. Lewis: Multiple Twin of Cassiterite. Threefold twinning is well and regularly developed on opposite sides of the crystal, which consists of two main portions with twin axes all in one plane, and the triplets so formed are connected together in a somewhat irregular way. Further, some of the individuals are twinned along pyramid faces inclined to the general plane so that the back of the crystal is unlike the front.—Arthur Russell: An account of the Minerals found in the Virtuous Lady Mine, near Tavistock. The following species were met with: chalybite, in pseudomorphs after fluor and barytes, termed respectively 'boxes' and 'slippers' by the miners; marcasite in sheaf-like aggregates; mispickel in two modifications; anatase, on one crystal of which was found a small crystal of brookite, the only one seen by the author from this locality.—Dr. A. Hutchinson: Some Graphical Methods in Crystallography and Crystal Optics. Diagrams of expressions involving sines, such as $\sin E = \beta \sin V$, are much simplified by taking log sines for co-ordinates, the result being a series of parallel straight lines.—Dr. A. Hutchinson and W. Campbell Smith: Labradorite from St. John's Point, Co. Down. The large fresh crystals of felspar, which occur in a basaltic dyke, have physical characters—specific gravity 2·706, extinction on 010 and 001 —23° and —11° respectively, refractive indices α 1·5630, β 1·5665, γ 1·5712—which agree closely with the position of the felspar in the plagioclase series given by its chemical composition, which is approximately represented by the formula 33 Ab 5 Or 62 An.—Dr. G. F. H. Smith: Apparatus for preparing Thin Sections of Rocks. A description was given of the apparatus recently made for the Mineral Department of the British Museum.—Russell F. Gwinnell: Calcite Crystals from a Water Tank. The crystals, which were deposited during the dry summer of 1911 from water derived from a spring in the marlstone of Belton Park, near Grantham, Lincolnshire, averaged 0·1 mm. in greatest diameter, and showed the unusual unit rhombohedron form $10\bar{1}1$.

CORRESPONDENCE.

BEMBRIDGE LIMESTONE AT CREECHBARROW HILL.[1]

SIR,—As Mr. Keeping's latest Report on Creechbarrow Hill leaves the question of its true geological structure still somewhat uncertain, I venture to draw attention to one or two points which may, perhaps, be of some help towards arriving at a correct conclusion.

1. If the Pipeclay is to be relied upon as a datum-line, some idea can be formed of the approximate thickness of strata between it and the Limestone above.

2. Latest borings on the eastern flank have proved Pipeclay as high up as 393 feet O.D., at a horizontal distance below the summit of not more than 610 feet. Shown thus—

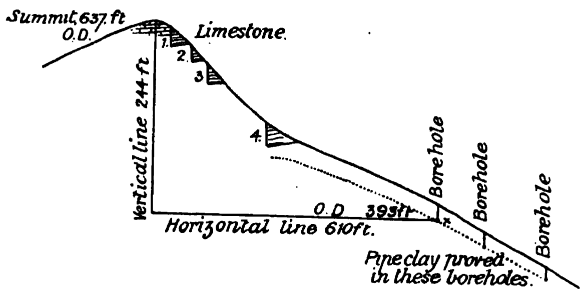


Diagram of Creechbarrow Hill, showing excavations and boreholes.

1, 2, 3, 4. Trenches which showed stratified deposits of gravel, large flints, sand, and clay, apparently dipping into the hill.

N.B. Most probably the outcrop of the Pipeclay is much higher up, leaving so much less space for later deposits.

[1] See British Association Report, Section C (Geology), Dundee Meeting, September, 1912, on Mr. Keeping's further examination of Creechbarrow Hill, Isle of Purbeck. (GEOL. MAG., November, 1912, pp. 509–10.)

3. There is a proved thickness of 166 feet of Bagshot Beds above the Pipeclay Series at Worgret Well, some 3½ miles away N.N.W. (See Proc. Dorset Field Club, vol. xxvii, p. 162.)

4. A 10 or 20 feet contoured plan on a fairly large scale, indicating where trenches and borings have been made and their sections already described, would be a useful aid to any keen geologist who may be interested enough to make further investigation.

A. H. BLOOMFIELD
(Twenty-five years Collector to the late Mr. W. H. Hudleston).

GRANGE ROAD, WAREHAM.
November 8, 1912.

FLINT IMPLEMENTS OF EARLY MAN: GEOLOGISTS' ASSOCIATION.

SIR,—Among the exhibits at the conversazione of the Geologists' Association held on Friday, November 1, at University College, London, was one by Mr. Hazzledine Warren, F.G.S., illustrating pressure-flaking upon flints produced experimentally.

Mr. Warren had adopted the method of fixing together with some cementing material two stones with the obvious intention of conveying the impression that in each case the stones so joined were the only two which had been used in producing the flaking upon the uppermost one. When, however, I examined one of the exhibits which showed the uppermost stone with two pressure 'bays', it was at once clear to me that these two hollows could, under no

Eolith from Plateau Gravel, Ightham. (Prestwich Collection.)

possible circumstances, have been produced by pressing it upon the underlying stone. On questioning Mr. Warren I elicited the information that he was unable to recollect whether the underlying flint *was* the one upon which the other had been flaked, and, after a long experience of flaking flints by pressure, I have confidence in stating that two such hollows as were shown could not be produced by pressing on any *single* stone of any sort or kind. As this question of the natural fracture of flint is of the utmost importance in deciding as to the 'humanity' or human origin or otherwise of certain ancient flaked stones, it appears to me most regrettable that Mr. Warren was not more careful in exhibiting reliable specimens. As also some of those present at the conversazione who did not closely examine Mr. Warren's specimens may have gone away with an erroneous idea of the flaking which can be produced by pressing one stone upon another, it seems desirable that this matter should be made public and all misunderstanding about it removed.

J. Reid Moir.

12 St. Edmund's Road,
Ipswich.

HOME-MADE NATURAL EOLITHS, 'THE WARRENS.'

Sir,—At the London Geologists' Association Soirée, November 1, 1912, there was a most interesting display of the 'Warrens' as made by Mr. Hazzledine Warren, F.G.S. Mr. Warren's method seems to me a fallacious way to prove a natural origin for the Eolithic 'Cupid's bow' type, such as he showed on Friday night. Surely the proof, if any, is that they are 'Warrens' and nothing more. For, first, Mr. Warren selects a form of Eolith he deems as quite a natural one, the 'Cupid bow', and then sets to work to see how best he can produce this by a machine he has made. Second, he selects a suitable piece of flint and, further, two equal-sized pebbles, places them securely in position, and applies and so controls the pressure as to produce the best results to him. It seems to me quite impossible to compare any procedure of nature with all this carefully thought out and carefully controlled mechanical one. Nature, too, shows all her productions, and such as he might deem her successes and failures. Surely to be fair Mr. Warren should do the same. He, too, must be more successful now than he was. Let him, then, so improve his methods and his machine and make, say, palæoliths and neoliths. Would not this prove that nature made *these*? Mr. Reid Moir's show was the opposite, as he produced his home-made rostro-carinate forms, but sought to prove that *man* made those. Surely this seems far more logical. I see now that as photographs have been taken under water showing the hooked trout fighting with the angler, we may yet hope to see such taken under the sea, showing how water-driven stones really do their work upon each other. In the absence of any facts mere speculation seems useless.

F. J. Bennett.

Acacias, West Malling.
November 13, 1912.

OBITUARY.

RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S. L. & E., F.G.S.

Born July 30, 1840. Died November 22, 1912.

It is with deep regret we record the death of our old and valued friend and fellow-worker in palæontology for so many years, Dr. R. H. Traquair, lately Keeper of the Natural History Collections in the Museum of Science and Art,[1] Edinburgh, which occurred on November 22, 1912, at his residence, "The Bush," Colinton, Midlothian, in his 72nd year.

Early in life he took a keen interest in fossil fishes, his attention having been arrested by discovering a portion of a Palæoniscid fish in the Wardie Shales. In passing his medical course in the University of Edinburgh, where he studied under Professor Goodsir and Sir William Turner, he chose as the subject for his medical thesis the asymmetry of the flat fishes, for which he was awarded a gold medal.

In 1866 Traquair became Professor of Natural History in the Royal Agricultural College, Cirencester; in 1867 Professor of Zoology in the Royal College of Science, Dublin; and in 1873 Keeper of the Natural History Collections in the Science and Art Museum, Edinburgh, a post which he held till his retirement in 1906.

At the Edinburgh Museum he had the charge of the collection of fossil fishes, and during thirty-three years he acquired a very fine series of fish-remains from the Old Red Sandstone and Carboniferous rocks of Scotland.

His researches led to the entire revision of the classification and nomenclature of Agassiz and other early investigators, especially in the Palæoniscidæ and the Platysomidæ, Traquair's work being based on the morphological structure, not on the mere outline of the body or the configuration of the scales and teeth.

During his long career Dr. Traquair published upwards of 130 papers on zoological and palæontological subjects, chiefly on fossil fishes, which have mostly appeared in the volumes of the Palæontographical Society, the Transactions of the Royal Society of Edinburgh, and the Royal Physical Society. Between 1871 and 1902 he also contributed about 30 papers to the GEOLOGICAL MAGAZINE. By means of the fish-remains he arranged the Carboniferous rocks of Scotland in two divisions, and on the same principle he established a triple classification of the Lower, Middle, and Upper Old Red Sandstone.

For several years he filled the office of Swiney Lecturer on Geology at the British Museum (Natural History), where he displayed his remarkable talent as a draughtsman on the blackboard. Much of his success in Ichthyology no doubt was the result of this graphic skill and accurate anatomical knowledge in drawing fossil fishes.

He was the recipient of many honours in recognition of his work. In 1881 he was elected an F.R.S. of London; the Lyell Medal was awarded him by the Geological Society in 1901, and a Royal Medal in 1907 by the Royal Society. His life and portrait appeared in the June Number of the GEOLOGICAL MAGAZINE for 1909 (pp. 241–50).

He was quite lately engaged on his final memoir on the Palæoniscidæ for the Palæontographical Society, and up to the very last of his life, even when his health had given way, he bravely continued his labours until the end.

His widow, two sons, and one daughter survive him.[2]

[1] Now known as the Royal Scottish Museum.
[2] In part from the *Scotsman*, November 23, 1912.

THE
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No. II.—FEBRUARY, 1913.

ORIGINAL ARTICLES.

I.—*Lophophyllum* and *Cyathaxonia*: Revision Notes on two genera of Carboniferous Corals.[1]

By R. G. Carruthers, F.G.S.

(PLATE III.)

THREE years ago when I was discussing certain Carboniferous Corals from Arctic regions the opinion was expressed that the genus *Lophophyllum* of Milne-Edwards & Haime had been erroneously interpreted by palæontologists, and that in reality it included Thomson and Nicholson's well-known genus *Koninckophyllum*.[2] The main object of the present communication is to substantiate this view with illustrative sections from topotypes, accompanied by some further observations on the genus. At the same time the opportunity is taken to deal with several points in the morphology of the similar genus *Cyathaxonia*; in the latter case the work is in the nature of a preliminary note rather than of a formal revision. Pending the appearance of a general memoir on the British Carboniferous Corals, it seems desirable that these notes should be published without further delay, as all these genera are commonly met with in zonal work. Most of the material has come either from the Geological Survey Collection or is in my own possession, but Dr. Vaughan has always been very helpful, while I have to thank Dr. T. F. Sibly for some unusually fine examples of *Cyathaxonia* from Matlock. Other specimens of this genus, from Yorkshire, have very kindly been sent to me from time to time by Dr. A. Wilmore, often at some personal inconvenience.

LOPHOPHYLLUM. (Pl. III, Figs. 1, 2, 3.)

The genus *Lophophyllum* was founded by Milne-Edwards & Jules Haime in 1850, when they published a description and figures of the genotype, *L. konincki*, in their monograph *Les Polypes Fossiles des Terrains Paléozoiques*.[3] The figured specimen was sent to them by de Koninck from Tournai, and is now apparently lost, since it could not be found amongst other figured material of theirs examined by the writer in 1907 at the Musée d'Histoire Naturelle, Paris.

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.
[2] "A Carboniferous Fauna from Nowaja Zemlja," by G. W. Lee, D.Sc., with notes on the Corals by R. G. Carruthers: Trans. Roy. Soc. Edin., vol. xlvii, pt. i (No. 7), p. 152, 1909.
[3] Loc. cit., p. 349, pl. iii, figs. 4, 4*a*.

In 1846, four years previous to the publication of the *Polypes Fossiles*, a similar coral had been figured and described by Michelin [1] under the designation *Cyathaxonia tortuosa*; his type also came from Tournai, but seems to be missing from the remnants of his collection, now stored in the Musée d'Histoire Naturelle. It may be remarked in passing that in other cases where the original specimens were available for comparison, Michelin's figures proved to be tolerably accurate, while those given by Milne-Edwards & Haime are remarkably faithful.

The work of both Michelin and of Milne-Edwards & Haime clearly shows that they were dealing with a coral which had a smooth epitheca and a prominent columella; in the absence of the holotypes, these characters are of great importance in recognizing their 'species'.

The general constitution of the Tournai fauna is well known, and the corals in particular have been exhaustively dealt with by de Koninck. From the published accounts, confirmed by a personal examination of four large collections and of many quarries round Tournai, it can be stated confidently that in this peculiar fauna there are only two coral species with a strong columella. One of these is Michelin's *Cyathaxonia cornu*, but as this is relatively very small, and has strong longitudinal ribbing on the epitheca, it is clearly not to be confounded with either *C. tortuosa* or *Lophophyllum konincki*. The remaining form agrees with the figures and descriptions of both of the last-named 'species', and it is therefore concluded that these are synonymous. Generically, the first of these corals is not a true *Cyathaxonia*, as it develops dissepiments in the mature growth-stages. Michelin's specific name can be retained, however, as it has considerable priority. The genotype of *Lophophyllum* is accordingly taken to be *L. tortuosum*, and a diagnosis is appended below.

Lophophyllum tortuosum (Mich.). (Pl. III, Figs. 1, 2.)

The chief references are—

1846. *Cyathaxonia tortuosa*, Michelin, *Iconographie Zoophytologique*, p. 258, pl. lix, fig. 8.

1850. *Lophophyllum konincki*, Milne-Edwards & Jules Haime, *Polypes Fossiles des Terrains Paléozoiques*, p. 349, pl. iii, figs. 4, 4*a*.

External Characters.

Corallum (see Pl. III, Figs. 1, 1*a*, 2).—Simple, cornute, frequently showing short root-like processes of attachment at the base. *Epitheca* thin, smooth, with fine annular striations, and a few constrictions of growth; traces of longitudinal ribbing very faint or absent entirely. *Calyx* deep. *Major septa* thin and reaching to the columella, which forms a long lath-like projection in the centre of the calyx. *Minor septa* well developed, thin; *dissepiments* appear round the inside of the calicinal wall, but are not a prominent feature. The *cardinal fossula* is deep, and lies on the convex side of curvature of the corallum.

[1] Michelin, *Iconographie Zoophytologique*, p. 258, pl. lix, fig. 8.

Internal Characters.

Transverse Sections (Pl. III, Figs. 1*b*–*e*).—All the septa extend to the epitheca throughout the coral, while in the younger growth stages there are no dissepiments, although these appear later on, in a narrow ring next to the epitheca (Pl. III, Figs. 1*d*–*e*). The major septa extend to the thin lath-like columella (which is a direct continuation of the counter septum) until the final growth-stages; they then become amplexoid and fall away, leaving a bare tabular area in the centre of the coral. Through this bare central area the columella continues to project, surrounded by thin wavy lines, representing the edges of upraised tabulæ cut off by the plane of sections (Pl. III, Fig. 1*e*). At this stage the columella is often fringed with small projections, which are the remnants of attached septa; their length varies according to the proximity of the section to a tabula, the septa being always most fully developed on the upper surface of a tabula.[1] The large cardinal fossula is especially prominent in the younger growth-stages, when it is expanded inwardly and completely enclosed by the major septa (Pl. III, Figs. 1*b*–*c*).

Vertical Sections (Pl. III, Fig. 1*f*).—The tabulæ rise steadily up to the columella, but there is no central zone in which they are closer and more sharply elevated, as in other Clisiophyllids (*Dibunophyllum*, etc.). The columella is continuous throughout, while the dissepiments are small, forming a narrow outer ring of two or three rows only.

Distribution.

The opportunity is here taken to discuss the horizon and fauna of the Carboniferous Limestone around Tournai, from which so many corals, including those now under consideration, were originally described.

De Koninck and his predecessors simply gave 'Tournai' as the locality for many of their fossils. The district[2] has for long been a favourite hunting-ground with collectors, on account of the remarkably perfect condition of the fossils; they are silicified, and can be picked out of a soft matrix in the vertical fissures of decalcified limestone which traverse the quarries. There are scores of quarries around Tournai, and the fauna is rich and varied. At first sight, therefore, the mere word 'Tournai' would seem to be insufficient as a locality index, more especially as a list of forms so recorded shows a mixture of species which are zones apart in most British areas (e.g. the South-Western Province). Nevertheless, actual inspection of the ground shows that this intermixture is a fact. Additional proof is thereby accorded to the contention (readily admitted by Dr. Vaughan) that the English 'zones' are in some degree based on a non-genetic sequence of faunas determined by a given set of

[1] A parallel instance has been fully described and illustrated in *Caninia cornucopiæ*, see this Magazine, Dec. V, Vol. V, p. 165, Diagram F, 1908.

[2] The Tournai region has been treated in detail in a valuable and comprehensive stratigraphical study of the Lower Carboniferous rocks of Belgium and their relationship to British areas. See M. Delépine, *Recherches sur le Calcaire Carbonifère de la Belgique*, pp. 214–41, Lille, 1911.

physical conditions, and accordingly liable to considerable lateral change and variation.

I have lately had an opportunity to see part of the Belgian sequence under the guidance of M. Delépine. The limestones round Tournai are remarkably flat, so that the numerous large quarries are practically all on the same horizon, ascribed by M. Delépine to the C or Upper Tournaisian sub-zone of Dr. Vaughan's scheme. The assemblage of corals in the quarries visited (Baguette, Pont-a-Rieux, Vaulx, Allain, etc.) was much the same throughout; a typical list from Pont-a-Rieux gives, in order of abundance: *Caninia cornucopiæ*, *Cyathaxonia cornu*, *Zaphrentis omaliusi*, *Z. densa*, *Amplexus spinosus*, *Caninia patula*, *Zaphrentis konincki*, *Z. delanouei*, *Lophophyllum tortuosum*, and *Syringothyris* sp. There were also two species of *Michelinia* and some '*Paleacis*'-like forms, not yet fully identified. *Caninia cylindrica* was not noticed here; M. Delépine has found it at a slightly higher horizon at other quarries in the district.

I also noticed several specimens of *Lophophyllum tortuosum* in the Calcaire de Landelies, along the banks of the Sambre; the level here is given by M. Delépine as Z_2, and is accordingly slightly lower than at Tournai. In Dr. Vaughan's collection from the Bristol district there is an isolated example of this species from the Z_2 sub-zone, and in the Geological Survey Collection there is another specimen from this level in South Wales (Pr. 2933). I have recognized another example collected by Mr. John Smith, of Dalry, from the Lower Limestone of Castletown in the Isle of Man.[1] This specimen (quite normal, except that the dissepiments begin earlier) is of unusual interest, because the horizon seems to be well up in the Visean, and indeed has been considered by Dr. Wheelton Hind to belong to the D_2 sub-zone.[2] Otherwise *L. tortuosum* appears to be a characteristically Tournaisian species.

Remarks.

Lophophyllum tortuosum must certainly be grouped with those corals referred to *Koninckophyllum* at the present time. But the latter genus was founded by Thomson & Nicholson in 1876,[3] long subsequent to *Lophophyllum*, which these authors (relying on the original diagnosis, instead of the re-examination of topotypes) regarded as a Zaphrentid coral with one of the major septa prolonged and thickened. This conception has been followed by other writers, especially in America.

The *Koninckophylla* are occasionally compound, but it does not seem possible to separate such forms generically; the few that are characteristically compound (e.g. *Koninckophyllum proliferum*) can sometimes be found as 'simple', or isolated, coralla, and in all other respects their differences from *Lophophyllum tortuosum* are merely specific. I would suggest, therefore, that the genus *Koninckophyllum* of Thomson & Nicholson, and also those corals referred by Thomson to

[1] Trans. Geol. Soc. Glasgow, vol. xiv, pt. ii, p. 151, 1911. In the lists appended to this paper most of the corals have been named by Mr. Smith himself.

[2] Proc. Yorks Geol. Soc., vol. xvi, pt. ii, p. 150, 1907.

[3] Ann. Mag. Nat. Hist., vol. i, p. 297, 1876.

Acrophyllum,[1] should be abandoned, on the score of priority, in favour of *Lophophyllum*, of which an amended diagnosis may be given as follows:

Corallum simple and turbinate. Major septa meeting in the centre of the coral in the early growth-stages. One of the septa, usually the counter septum, is strongly thickened at the inner end, giving rise to a prominent *columella*, which may be discontinuous. In the more mature growth-stages the columella persists, but the septa usually retreat from the centre and become amplexoid, while dissepiments appear between the tabulæ and the wall. The tabulæ are arched upwards in the centre to a varying degree, but, unlike such genera as *Dibunophyllum*, there is no central zone where the tabulæ are more numerous or vesicular, nor is there a system of vertical lamellæ distinct from the septa.

Those corals referred by Nicholson & Thomson and other authors to *Lophophyllum* (e.g. *L. proliferum* and *L. eruca*) do not develop dissepiments at any stage of growth, and are essentially *Zaphrentes* having one of the septa thickened at the inner end. It may be convenient at some future time to group them as a sub-genus of *Zaphrentis*, but for the present such a course is not considered advisable.

Notes on the Lophophylloid columella.—The columella of a *Lophophyllum* is not, as in *Cyathaxonia*, a structure independent of the septa; on the contrary, it is simply a direct continuation of one or more of the major septa (usually the counter septum, sometimes of the cardinal or other major septa in addition). This fact is brought out on examining a thin vertical section, cut as nearly as possible down the centre line of the counter septum. Such a section is shown on Pl. III, Fig. 3, the subject being a '*Koninckophyllum*' from the Scottish Lower Limestone Group (approximately of D_2 age). In this section the fine radiating striæ represent the crystalline fibres of the skeleton; these spring from dark points, which are arranged in ill-defined linear series, one for each layer of growth. When these lines are followed inwards from the outer end of the septum (right-hand side of figure) they are seen to curve downwards and then gradually rise towards the centre of the coral, where they have a dome-like arrangement (the 'columella'). It is accordingly clear that there was continuous deposition of material along the upper edges of both septum and 'columella', and that the latter is, essentially, a mere continuation of the septum. The case is different in *Cyathaxonia*, as will presently be shown.

Genus CYATHAXONIA, Mich. (Pl. III, Figs. 4–10.)

The genotype of *Cyathaxonia* may be taken as *C. cornu*[2]; as in the preceding case, the type-specimen is lost, but the original figures

[1] Thomson was mistaken in his conception of this genus, which was distinctly stated by Nicholson to have no columella. Good figures of the genotype, *A. oneidense* (Billings), are given by Lambe in *Contrib. to Canadian Pal.*, vol. iv, pt. i, pl. xvi, figs. 1, 2, 1899.

[2] No genotype was given by Michelin; Milne-Edwards and Haime selected *C. cornu*, and their example is here followed, for reasons which will be explained in detail elsewhere. This course does no injustice to Michelin: whereas a rigid interpretation of the law would necessitate a radical change in the long-established conception of *Cyathaxonia*, and this for purely academic reasons.

and description amply suffice, there being no risk of confusion with any other Tournai fossil.

Tabulæ.—Apparently it has always been supposed that this beautiful little coral had no tabulæ, being open from top to bottom. Chiefly on this ground the genus has been placed in a family apart from other Palæozoic corals (the Cyathaxonidæ of Milne-Edwards & Haime), which has supplied material for much ingenious speculation as to possible descendants amongst the Hexacoralla. As a matter of fact, tabulæ are present in abundance; they are, however, very thin, and doubtless the misconception arose because these little fossils, as found at Tournai, are invariably silicified, and so fragile that tabulæ are not apparent on breaking open a specimen. But if the coral be first steeped in hot Canada balsam, and then carefully ground down, a thin section can be made, in which the tabulæ are clearly seen, rising upwards to the strong central columella (Pl. III, Fig. 6). When the specimens are calcareous, as are most of those from British and Irish localities, vertical sections showing tabulæ are readily obtained, although microscopical examination is generally requisite, owing to the very small size of this species.

Columella.—At the extreme tip of the corallum no trace of a columella can be seen, the septa simply meeting at the centre.[1] When eight or nine septa have developed (the number varies considerably) the columella appears, and quickly attains prominence.

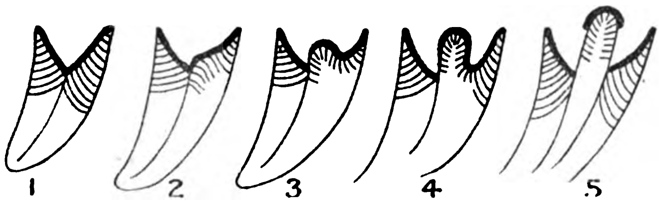
Both vertical and transverse sections show that the columella is, structurally, quite independent of the septa. Thin transverse sections (Pl. III, Fig. 4) show the calcite fibres radiating outwards from a central point, usually dark; concentric coloured growth-rings are usually to be seen round this axis. The major septa are fused against the columella, but in no way partake in its construction, for their crystalline fibres and central dark or white line terminate as soon as the columella is reached (Fig. 4, Pl. III, is too small to illustrate this point, which is better seen in the section of *C. rushiana*, Fig. 10).

Vertical sections also demonstrate the independence of the columella and septa. The section shown in Fig. 5, Pl. III, is cut down the axial plane of the coral, along the centre of both the columella and of the major septum on each side. Here, again, the arrangement of the crystalline fibres (at right angles to which growth takes place) indicates the absolute lack of continuity between septa and columella, although these latter are in complete contact.

Compared with *Lophophyllum*, the columella of a *Cyathaxonia* may be regarded as an extreme case of the upward bending of a septum in the centre of a coral, developed to such a degree that severance has taken place and an independent structure arisen. This conception is here illustrated in diagram form, figures of two other forms being added to show progressive divergence from a typical *Zaphrentis*, although a phylogenetic connexion is by no means implied.

[1] The primary septation of *Cyathaxonia cornu* forms the basis of a paper by M. Faurot ("Affinités des Tétracoralliaires et des Hexacoralliaires": *Annales de Paléontologie*, tom. iv, 1909). This important communication deserves separate treatment, and is therefore only referred to here.

The tabulæ of *Cyathaxonia* do not contribute in any way towards the construction of the columella; they remain uniformly thin right up to their connexion with the latter, and never show any trace of passage into that structure. The columella of *Cyathaxonia* is therefore developed at a very early stage, and it is built up round an imaginary central axis, remaining throughout quite independent of septa or tabulæ, although these are in complete contact with it. In Dr. Vaughan's species, *C. rushiana*, the columella is relatively larger than in *C. cornu*, and in transverse sections shows a marked elongation in line with the cardinal fossula. This is occasioned by the radiation of the crystalline fibres from an imaginary l i n e instead of a p o i n t; this 'line' is usually either darker or lighter than the rest of the columella, although occasionally no colour differentiation can be seen. With the exception that most specimens are three or four times larger than *C. cornu*, there is no further difference between the two species, and all gradations can be found between them.



Diagrammatic representation of vertical sections cut down septa, in the cardinal-counter septal plane, illustrating the formation of the columella in *Lophophyllum* and *Cyathaxonia*. Thick lines indicate growth region; thin lines, direction of crystalline fibres.

FIG. 1. *Zaphrentis omaliusi.*
,, 2. *Zaphrentis eruca* (*Lophophyllum* auctt.).
,, 3. } *Lophophyllum* (*Koninckophyllum* auctt.).
,, 4. }
,, 5. *Cyathaxonia cornu.*

Septa.—Both *C. cornu* and *C. rushiana* have very long minor septa, which appear at a very early period, when perhaps only seven or eight major septa have developed. These minor septa all lean inwards away from the cardinal fossula, and each one ultimately fuses with a major septum; the pair in the counter fossula (one on each side of the counter septum) are longer than the rest (Pl. III, Figs. 4, 9, and 10) and invariably appear first, sometimes before the conclusion of the protoseptal stage, with six primary septa. They are not formed by a splitting of the major septa, but are minor septa in the strict morphological sense, as is shown by their development and by their relation to the vertical furrows on the epitheca. On examining a good specimen it will be noticed that each alternate furrow coincides with one of the longer series of septa, and each furrow between corresponds to one of the shorter series. The latter are therefore the minor septa, this rule holding good in all Rugose corals. The remarkable length of the minor septa, and their general disposition, frequently aid in the recognition of these two species, especially when silicification has obscured the columella.

Carinæ.—There is another peculiarity which can often be noticed in either species. In transverse sections little jagged projections may be visible along the edges of the septa (see Pl. III, Fig. 9). In a vertical section cut parallel to, but not quite touching, the face of the septa these projections are seen to be spines, which are arranged in linear series parallel to the free edges of the septa (Pl. III, Fig. 8). They are, in fact, *carinæ*, such as are common enough in Devonian corals. The appearance of this phenomenon in Carboniferous times is somewhat of a mystery, for these structures do not seem to occur in Tournaisian specimens of *Cyathaxonia*, while they are often met with in strata of Visean age. Curiously enough, the only other Carboniferous coral where this feature seems to have been noticed (a new species of *Campophyllum*[1]) also comes from Visean beds. Septal projections in *Cyathaxonia* were first recorded by Dr. A. Vaughan.[2] He considered that they might be the remnants of tabulæ subsequently destroyed, a not unnatural view in the absence of vertical sections to demonstrate their true nature. As previously mentioned, carinæ have been observed in both *C. cornu* and *C. rushiana*. They are not traceable in examples of *C. cornu* from Tournai, and cannot be considered of diagnostic value in either species.

EXPLANATION OF PLATE III.

Photographed from camera lucida drawings (except Figs. 1, 1*a*, and 2).

FIG. Figs. 1–2, *Lophophyllum tortuosum* (Mich.).

1. Profile view. Nat. size. Cornet Quarry, Tournai.
1*a*. Calyx of above specimen. Nat. size.
1*b–e*. Serial transverse sections from above specimen. Nat. size.
1*f*. Vertical section from middle portion of above. Nat. size.
2. Another specimen. Side view with part of calyx broken away, showing the columella. Nat. size.
3. *Lophophyllum* sp. (*Koninckophyllum* auctt.). Vertical section. × 3. Petershill Quarry, Bathgate.

Figs. 4–7, *Cyathaxonia cornu*, Mich.

4. Central part of transverse section. × 8. Southford Quarry, Dunfermline.
5. Part of median vertical section down septa and columella. × 8. Southford Quarry, Dunfermline.
6. Vertical section, showing the tabulæ. × 2. Cornet Quarry, Tournai.
7. Transverse section. × 2. Cornet Quarry, Tournai.
8. Vertical section, showing tabulæ and carinæ. × 5. Stock, near Bracewell.
9. Transverse section from above, showing carinæ. × 5.
10. *Cyathaxonia rushiana*, Vaughan. Central part of transverse section. × 8. Bradbourne, Derbyshire.

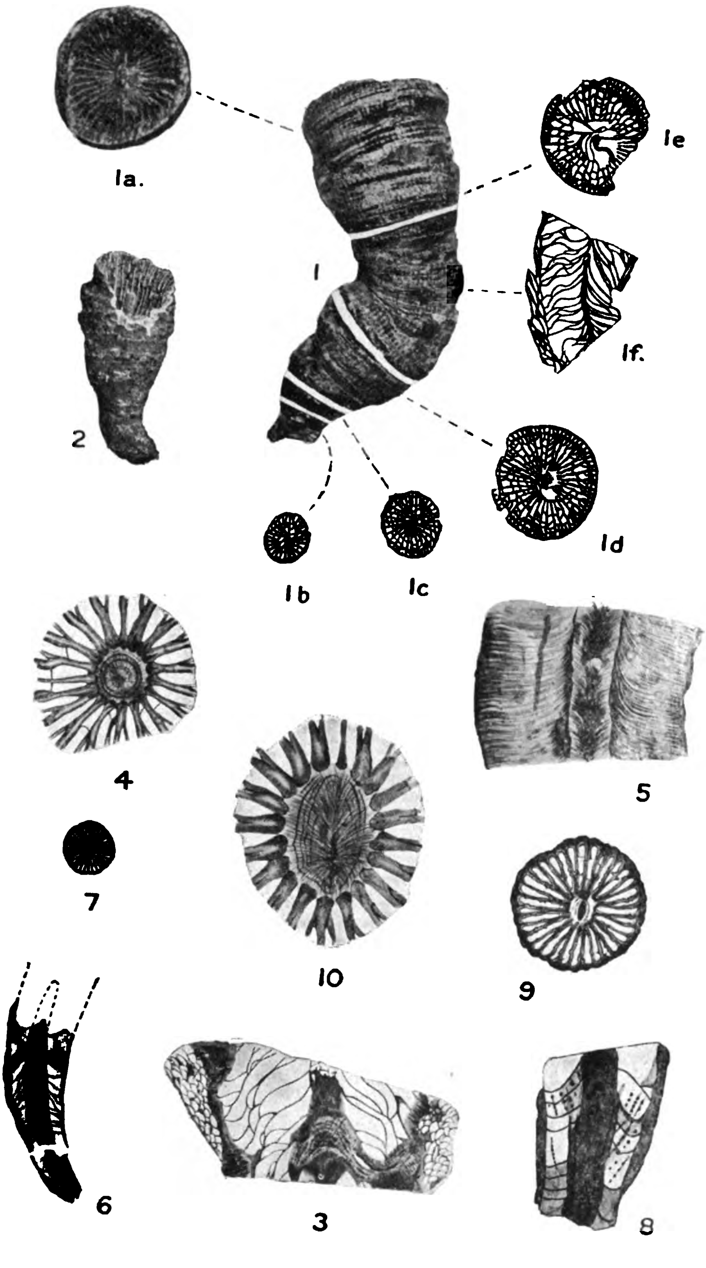
II.—The proposed Recognition of Two Stages in the Upper Chalk.

By R. M. Brydone, F.G.S.

IN the Geological Magazine for July and August last Mr. A. J. Jukes-Browne made a proposal for the recognition in England, France, and Germany of a boundary-line between two corresponding

[1] Lee & Carruthers, loc. cit., p. 150, pl. i, figs. 3–6.

[2] "The Carboniferous Succession at Loughshinny": Q.J.G.S., vol. lxiv, p. 460, 1908.



R. G. Carruthers photo.

Lophophyllum and *Cyathaxonia*.

stages in the middle of the old zone of *Actinocamax quadratus*. The reception to be given to this proposal so far as it concerns France and Germany must be a matter for the geologists of those countries, and I am concerning myself chiefly with the proposal as it affects the English Chalk. Inasmuch as I sympathize with the proposal, and my own work is partly relied upon, it may seem ungracious in me to criticize it, but there are several points on which criticism seems desirable if only to afford Mr. Jukes-Browne an opportunity of replying while the subject is still fresh.

In the first place, he appears to intend at the top of p. 306 to endorse a proposal by me to constitute a new zone, the zone of *Offaster pilula*, for the reception of the lower two out of the three subzones into which Mr. Griffith and I divided the old zone of *A. quadratus*. It is, however, not very clear that this is so, and any uncertainty is rather unfortunate, as when he wrote my proposal was still unpublished, being taken by him from letters in which I told him that I was about to publish such a proposal and gave my main new grounds in order to obtain his opinion as to the permissibility of a subsidiary proposal. It was, perhaps, inevitable if he could not wait for the publication of my proposal—now happily accomplished[1] —that he should quote from these letters; but it seems hardly fair that in doing so he should ignore the new grounds on which the proposal was based, or that he should write on p. 369 that the line at the top of the zone of *O. pilula* had not yet been accurately determined in England when the letters from which he apparently drew the main proposal of a zone of *O. pilula* in England showed that this line *had* been accurately determined in South England, to which my proposal was limited.

In the second place, in his list of zones on p. 308 the zone above that of *Marsupites* appears as the "zone of *Offaster pilula*". At the foot of p. 310 it appears without warning as the "zone of *Actinocamax granulatus*". In Table II it appears again without warning as the "zone of *Offaster pilula* and *Actinocamax granulatus*". In Table III it again changes to "zone of *Offaster pilula*", in Tables V and VI to "zone of *Offaster pilula* and *Actinocamax granulatus*", in Table VII to "zone of *Offaster pilula*", and finally in Table IX to "zone of *Offaster pilula* and *Actinocamax granulatus*". These apparently arbitrary intrusions of *A. granulatus*, when read with the statement next but one to be criticized, leave me practically certain that Mr. Jukes-Browne intended, at any rate during part of the time he was writing, to lay it down that the ranges of *A. granulatus* (upwards from the *Marsupites* zone) and *A. quadratus* (below the *Belemnitella mucronata* zone) corresponded with the two divisions of the old zone of *A. quadratus* on which he was working.

I am afraid that on this point he may have fallen into a trap which I certainly laid for him, though quite unwittingly. In "The Zones of the Chalk in Hants", *A. granulatus* appears as having occurred in four of the collated pits in the *subzone* of *O. pilula* (which is the upper part of the new *zone* of *O. pilula*). All the specimens in question

[1] See *The Stratigraphy of the Chalk of Hants*. London, Dulau & Co., Ltd., 1912.

were, I believe, found before the range and characters of *A. granulatus* were fully realized and were recorded in fact as *A. quadratus* simply on the strength of their granulation and general horizon. These records were, I believe, gradually transmuted into *A. granulatus* in consequence of an impression which prevailed for some time, as the result of putting together—

(1) Dr. Rowe's statement that all the Belemnites found by him in the old zone of *A. quadratus* on the Sussex coast proved to be *A. granulatus*, and

(2) My own knowledge that the Sussex coast sections included not only very long exposures of the whole of the zone of *O. pilula*, but also very considerable exposures of the lower part of the restricted zone of *A. quadratus*,

that *A. quadratus* did not extend outside the restricted zone of *A. quadratus* and was probably limited to the upper part of even that restricted zone, and that any *Actinocamax* from any lower horizon was presumably *A. granulatus*. When therefore I came to prepare the table of fossils in "The Zones of the Chalk in Hants" the material supplied to me included these four specimens as *A. granulatus*, and I tabulated them as such on the principle enumerated in the second paragraph of the introduction to the table. One of these specimens has since been demonstrated to come from a pit in the restricted zone of *A. quadratus* and so was probably really an *A. quadratus*, and if really an *A. granulatus* does not assist the theory of distinct ranges for these two Belemnites; and of the other three records one is a traditional record before 1890 from a pit now known to include the base of the restricted zone of *A. quadratus*, another is based on a specimen not sufficiently complete to be positively identified, and the third on a specimen that has long been lost sight of. These records do not therefore constitute any reliable evidence on the present question.

But whether Mr. Jukes-Browne was or was not relying partly on them, I regard the suggestion with dismay. My personal experience in Hants corresponds exactly with that experience of Dr. Blackmore in Wilts which Mr. Jukes-Browne (naturally) characterizes as exceptional, and I have two specimens from Sussex which I expect to prove that there also *A. quadratus* ranged down at least into the upper division of the zone of *O. pilula* and probably also into the lower, and I possess no evidence that *A. granulatus* occurs in the upper division of the zone of *O. pilula*.

But even if there are areas in which the boundary dividing the zone of *O. pilula* from the restricted zone of *A. quadratus* does seem to correspond with a line dividing the range of *A. granulatus* from that of *A. quadratus*, the contrary evidence of Hants and Wilts does not stand alone. A single pit at Bramford, near Ipswich, has yielded *A. granulatus* (determined by Mr. Jukes-Browne himself and recorded by him in *The Cretaceous Rocks of Britain*, vol. iii, p. 246) and *Belemnitella mucronata* (found by me, determined by Dr. Blackmore, and included by Mr. Jukes-Browne in the table on p. 247 of the last-mentioned work). There is therefore a possibility that the range of *A. granulatus*, already known to be a very long one, may overlap even that of *B. mucronata*, and it is very dangerous to base any classification on the assumption that it never overlaps that of *A. quadratus*.

The next point to catch my eye is the tabulation of *A. verus*, *A. quadratus*, and *B. mucronata* as having absolutely distinct ranges in Belgium. In a paper by M. Rutot (Bull. Soc. Belge Geol., tome viii, pp. 145–194, 1894) it is strongly emphasized that in a division consisting of pure white chalk and known as the "craie de Trivières" (and in one case, to judge from a section given, in an exposure of the upper part only of that subdivision) the three Belemnites above mentioned are found associated. Unless this statement has since been very thoroughly disproved it is dangerous to tabulate the ranges of *A. verus* and *B. mucronata* as separated by two whole zones.

The next point for consideration is the statement (previously alluded to) on p. 313 that it is a fact that the highest beds in the Yorkshire cliffs belong to the zone of *O. pilula*; in other words, that there is no chalk of the restricted zone of *A. quadratus* exposed in the Yorkshire cliffs.

Now it is obvious that if this statement ought to be accepted as an unquestioned fact, it cannot have been demonstrated in any earlier publication, and the argument proving it must be sought in Mr. Jukes-Browne's paper; and it would seem to be an essential element of such an argument that some test should have been established by which the boundary between the zone of *O. pilula* and the restricted zone of *A. quadratus* in Yorkshire can be determined and recognized with reasonable certainty. No such argument or test is directly stated, but it appears to be implied that the absence of *A. quadratus* has been treated as such a test. This is not a test for South England, and even if it has been absolutely demonstrated on the Yorkshire coast—and there is an immense difference in the case of *A. quadratus* between "has not been found" and "does not occur"—it remains to be proved that it is a valid and conclusive test for Yorkshire. This leads on to a point which goes to the root of the reliability of many of Mr. Jukes-Browne's instances of fossils which do occur in the zone of *O. pilula* but do not occur in the restricted zone of *A. quadratus*, and which is best explained by a concrete case. Mr. Jukes-Browne cites *Inoceramus lobatus* as occurring in the zone of *O. pilula*, but not in the restricted zone of *A. quadratus*. This citation must, from his general remarks, be based on statements in Mr. Woods' monograph. There we find *I. lobatus* recorded only from Yorkshire, but from many places in that county. How can any degree of reliability attach to the statement that this species occurred always below, never above, a line which has not yet been determined? This consideration would seem to rule out the employment of any specimens recorded from the old zone of *A. quadratus* in Yorkshire as evidence in establishing a stage break in the middle of that zone. I am afraid it also tends to the conclusion that it is dangerous to employ for that purpose many of the records from the South of England so employed by Mr. Jukes-Browne, although conditions are less unfavourable there, as Mr. Jukes-Browne adopts, by reference to "The Zones of the Chalk in Hants", definitions of the boundary in Hants which, while not very precise, might well enable it to be identified in other counties in a cliff or good pit section. At the same time it is hardly likely that any collections from the old zone of *A. quadratus* made before 1911, when Mr. Griffith and I first published our proposed subdivisions of it, were either made or labelled with such close attention to the particular planes of division that we adopted, or otherwise so accurately labelled as to precise locality, that they can, except in rare cases, be now definitely referred to one of those subdivisions.

The difficulty is best shown by a concrete case.

Mr. Jukes-Browne credits the zone of *O. pilula*, but not the restricted zone of *A. quadratus*, with *Inoceramus tuberculatus* and *I. pinniformis* on the strength, according to his own showing, of Mr. Woods' citation of both these species from the zone of *A. quadratus* of Brighton and Yorkshire. The 'Brighton' specimen of *I. tuberculatus* was collected by Dr. Rowe, probably before 1900; the 'Brighton' specimen of *I. pinniformis* before 1871. It is quite possible that since the beginning of 1911 the exact spot at which *I. tuberculatus* was found has been pointed out by Dr. Rowe or identified from bearings furnished by him, and its position with reference to the divisions made by Mr. Griffith and myself (which are absolutely reproduced on the Sussex coast) worked out, and it is also just possible that the same has been successfully done with the 'Brighton' specimen of *I. pinniformis*; but it is not stated to have been done, and nothing less would justify the use of these 'Brighton' specimens in distinguishing the zone of *O. pilula* from the restricted zone of *A. quadratus*.

Another question which arises in connexion with the Yorkshire Chalk is whether, if the whole or part of a zone other than the restricted zone of *A. quadratus* can be identified as succeeding the zone of *Marsupites* in Yorkshire, that zone is properly labelled "zone of *Offaster pilula*".

Now it was long ago pointed out by Barrois that the highest Chalk of Yorkshire showed strong signs of affinity to the German Chalk, and Dr. Rowe has furnished us with plenty of evidence that during several Chalk epochs, one of them being the epoch succeeding the zone of *Marsupites*, there is strong evidence of restriction in the affinity between Yorkshire and South England, owing probably to a high submarine ridge between them. On the particular evidence that in the Anglo-Parisian basin the zone of *Marsupites* is succeeded by a zone which is characterized by *O. pilula* and does not contain *Scaphites binodosus*, that in the North German basin the zone of *Marsupites* is succeeded by a zone which is characterized by *S. binodosus* and does not contain *O. pilula*, and that in Yorkshire the zone of *Marsupites* is succeeded by a zone which contains *S. binodosus* in abundance but in which *O. pilula* is scarce, it seems highly probable that Yorkshire at that time was essentially an arm of the North German basin and that the Yorkshire zone should be termed the zone of *S. binodosus*, and that in an inquiry as to synchronism in the Anglo-Parisian and North German basins Yorkshire fossils should appear in a different table from South English fossils, and that tests which are valid in South England may be quite fallacious in Yorkshire.

In the next place in the table on p. 372 the zone succeeding, as a 'continental' zone, the zone of *Marsupites* is given as the zone of *O. pilula* (on p. 369 it seems to appear as the "zone of *O. pilula* and *S. binodosus*"). It seems hardly prudent to ignore the part played by *S. binodosus*; and as *O. pilula* and *S. binodosus* are practically alternative in occurrence the conjunction 'or' seems the better one and the 'continental' zone should bear the name of "zone of *O. pilula* or *S. binodosus*". In the same table the Turonian is made to include the zone of *M. cor-anguinum* by what is obviously a printer's error of transposition of two brackets, but it is disconcerting as it stands.

Finally, a minor point of discord is to be found in the female gender of the varietal names of several varieties of *Echinocorys scutatus*. If they stood alone they could no doubt be absolutely justified on the ground that the name is an adjective whose nominative is 'var.', which stands for 'varietas', a feminine noun. But this line of defence is blocked by instances such as e.g. *Inoceramus inconstans*, var. *striatus*. It looks like a result of the use of two generic names of different genders for the same genus in different parts of the paper, while all the varietal names have been made to agree with one of them. It gives, however, a somewhat unfortunate suggestion of blunder on the part of the authors of the varieties.

It may not be inappropriate to take this opportunity of mentioning by way of postscript that I still retain the opinion expressed in *The Zones of the Chalk in Hants* that the subzone of *O. pilula* of that work would be best treated as a separate zone, and that I should have done so if I could have seen how in that case to deal with the subzone of *E. scutatus*, var. *depressus*; but it has always appeared to me impossible to unite the latter with the zone below it, and very difficult to endow it with zonal rank, and the only alternative was to unite it with the zone above.

Further, the plane which I have adopted as the top of my zone of *O. pilula* is one which is identifiable by palæontological (and often lithological) evidence of most exceptionally definite and easily recognizable nature, and it was hardly possible for a fieldworker, chiefly engaged on pits, to ignore it. But it is undoubtedly the case that the peculiar fauna of the subzone of abundant *O. pilula*, other than *O. pilula* itself, does not die out suddenly, like *O. pilula*, but gradually over a distance generally about 8 or 10 feet, and which in the Salisbury area is probably not less than the 25 feet necessary, according to Dr. Blackmore's measurements, to embrace the whole of the bed to which *Belemnitella lanceolata* is restricted, and which also contains *Aptychus leptophyllus* in abundance.

There is therefore substantial ground for the theorist to argue that the zone of *O. pilula* (or, which is practically the same thing, the subzone of abundant *O. pilula*) must be extended above the upper boundary which I have drawn for it. I have not, however, been able yet in Hants or Sussex to trace in practice any easily recognizable line marking the general disappearance of this fauna or even that any two of its elements disappear simultaneously. At the same time if a means could be devised for including fossils from any beds in which this fauna lingers with those of the zone of *O. pilula* without sacrificing the field value of the upper boundary I have drawn, it would be a substantial improvement on any suggestion yet put forward.

III.—On some Chalk-pebbles from the Floor of the English Channel.

By A. J. Jukes-Browne, F.R.S., F.G.S.

In 1908 Mr. R. H. Worth described a number of stones which had been dredged by Mr. T. R. Crawshay, of the Marine Biological Association, from the floor of the English Channel to the east and south-east of the Lizard.[1] These stones included a great variety of rocks such as granites, felsites, diorites, and other igneous rocks, gneisses, schists, slates, and quartzites, Devonian grits, Permian conglomerate, Triassic marl, sandstones of different kinds, Liassic limestones, hard chalks, and flints.

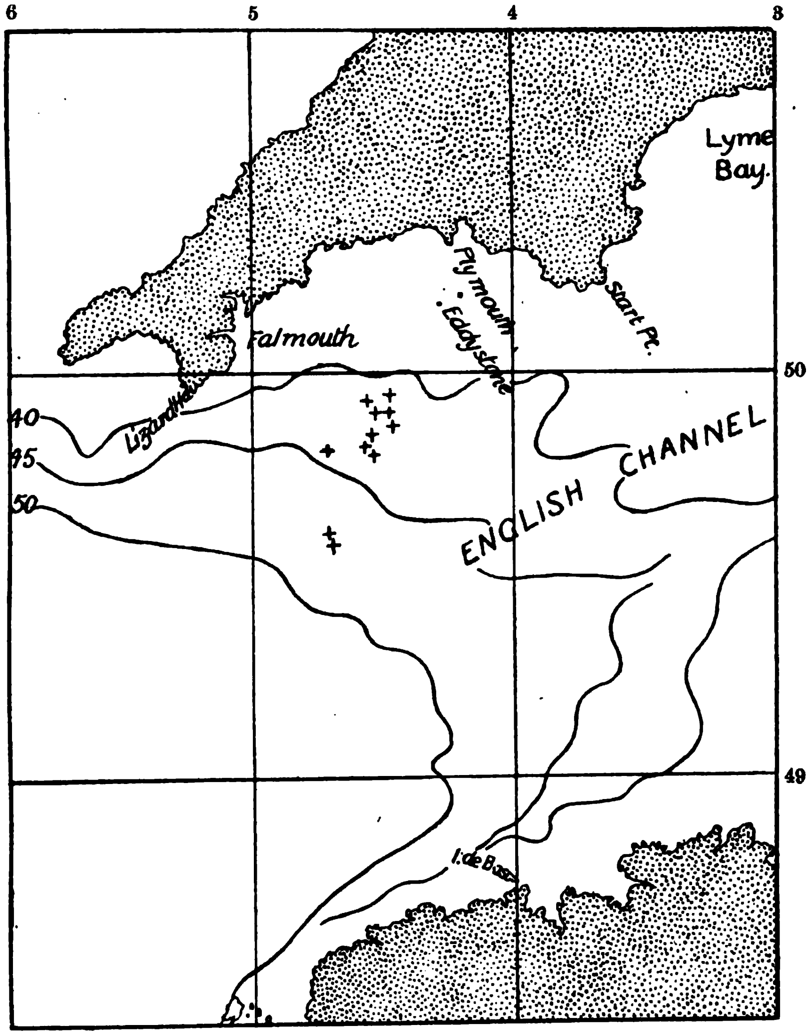
The majority of these stones and all the chalk-pebbles were obtained from depths between 40 and 50 fathoms in an area to the south of N. lat. 50° and about midway between the lines of 4° and 5° W. long. (see Map, p. 63). Mr. Worth has enumerated all the different varieties of rocks in this interesting assemblage, and has given particular descriptions of most of them from microscopical examination. Of the chalk-pebbles he observes, "a very hard yellow or cream-coloured chalk is of frequent occurrence; generally the exterior of the pebble is brown, and this colour extends some slight depth into the stone, getting less in intensity until it fades into the yellow or cream colour. Unless the stone happens to be much bored it usually requires a considerable blow to break it."

Mr. Worth prepared slides from five of these pebbles, and briefly mentions the composition of four of them, but describes the fifth in more detail. This pebble was about 3 inches long, stained orange-brown outside and yellow for a depth of 7 mm., all the inner part being cream-coloured. It included a nodule of green-coated chalk, the interior of which was reddish with cream-coloured markings, these latter proving to be borings made by some animal before embedment and filled with the material of the surrounding chalk matrix.

After describing a slice cut through this included nodule, Mr. Worth remarked that "the affinities of this yellow chalk appear to be with the 'Melbourn Rock' described by Mr. A. J. Jukes-Browne and later by the same author in collaboration with Mr. W. Hill", but he adds, "whether lithological similarity in this case implies identity of age may be doubtful." He does not seem to have made comparisons with any other part of the Chalk, and does not even mention the possibility of its being Chalk Rock.

[1] Journ. Marine Biol. Assoc. for 1908, p. 118.

As the description and photographs of this chalk-pebble seemed to me to agree much more closely with the Chalk Rock than the Melbourn Rock, and as Mr. Worth had not ventured to refer the



Map showing the spots, marked by crosses, where chalk-pebbles were found. The lines in the Channel are the contours of 40, 45, and 50 fathoms.

other specimens to any particular horizon, I asked him if he would allow me to examine the slides, and whether he could send me some of the other pebbles which had not yet been sliced. In response to this request he kindly sent me the five slides, as well as two others subsequently made, and a few of the other pebbles. Some of the latter were too much eaten away by boring animals to allow of cutting, but Mr. W. Hill has succeeded in making slides from six of them, and to his kindness in so doing I owe the opportunity of examining their structure. Mr. Hill has also examined all the slides and concurs in the conclusions at which I have arrived.

Mr. Worth's Slides.—It will be convenient to deal with these first. M. 14*a*: This is the specimen which was specially described by Mr. Worth, and it is undoubtedly comparable with the Chalk Rock of the midland and southern counties and with the rocky beds which occur in the zone of *Holaster planus* in Devonshire. No one who was familiar with the structure of the different zones of the Chalk could mistake it for Melbourn Rock. It exhibits the same variety of included organic fragments which is so constant a character of the Chalk Rock, and it contains numerous small grains of yellow-green glauconite, a mineral which is of frequent occurrence in the Chalk Rock, but is never present in the Melbourn Rock.

Again, the material of the included nodule differs from that of the surrounding substance in the same way as the included nodules of the Chalk Rock differ from the mass of that rock. In each case the component materials are the same, but there is a larger proportion of the fine-grained matrix in the nodule than in the surrounding chalk, and rather fewer of the larger fragments, such as pieces of shell and plates of Echinoderms. In other words, the nodules appear to be portions of the same deposit, but sifted by current action and indurated before being embedded in a fresh deposit.

The included nodule in the dredged pebble contains grains of glauconite, and it is in every respect similar to those of the Chalk Rock and different from those in the Melbourn Rock.

Mr. Hill and I possess slides of Chalk Rock from Cruxton, near Maiden Newton in Dorset, from Combe Beacon, 3 miles north-west of Chard, from Membury, north of Axminster, and from Pinhay, near Lyme Regis. The first two are typical Chalk Rock with glauconite grains, and are similar in structure to the Channel pebble. The third does not contain glauconite, but is an interesting slide, as it shows areas of typical Chalk Rock material passing gradually into others with a larger proportion of fine matrix and fewer shell fragments, the organic remains in the latter being chiefly foraminiferal cells and 'spheres', with sponge spicules, small Foraminifera, and shell debris (as in the nodules above-mentioned). The rocky chalk at the base of the *planus* zone at Pinhay shows the usual characters of Chalk Rock, but the glauconite grains are small.

The other four pebbles cut by Mr. Worth differ from that above described in not containing any glauconite and in having a larger proportion of the fine matrix with its complement of spheres and foraminiferal cells. Three of them resemble one another and the first one (M. 14*a*) in the variety of their organic contents, and consequently I think they may be referred to the zone of *H. planus*.

These slides may be described as showing a fine chalky matrix through which are scattered many cells and spheres, with a large number of small shell fragments, which always include some of Echinoderm plates and ossicles, as well as some *Inoceramus* prisms. There are also some perfect but small Foraminifera, such as *Textularia*, *Rotalia*, and small *Globigerina*; and a variable number of sponge spicules replaced by calcite and of cavities which have been occupied by spicules. Here and there larger pieces of shell or Echinoderm plates are to be seen.

They differ slightly from one another in such a manner as different pieces of chalk from the same zone might be expected to vary. Thus 21*c* and 26*a* have very few *Inoceramus* prisms and not many sponge spicules, while 72*b* is full of spicules and there are few prisms; 26*a* is also notable for containing a large piece of Echinid plate and a fragment of composite Polyzoan zoaria.

These slides agree very closely with one cut from a bed of hard rocky chalk in the middle of the zone of *H. planus* at Cruxton in Dorset, the No. 3 of the section given in *Cretaceous Rocks of Britain*, vol. iii, p. 119. This rock has the usual variety of contents, but most of them are small, and neither *Inoceramus* prisms nor sponge spicules are numerous. Further, there is no glauconite, so that its composition is really just the same as that of the 21*c* and 26*a* pebbles.

They also have much resemblance to the material of a piece of the *planus* zone obtained by Mr. A. C. G. Cameron from Annis Knob, near Beer. In the slide prepared from this the shell fragments are all small, except one large piece of Echinid plate, but sponge spicules are abundant, *Inoceramus* prisms fairly numerous, the perfect Foraminifera small, and there is no glauconite; so that this compares very closely with M. 72*b*.

Lastly, they are comparable with a slide cut from a piece of hard chalk from the zone of *Micraster cortestudinarium* at Pinhay, near Lyme Regis, for which I am indebted to Mr. A. W. Rowe. This is crowded with cells, spheres, small Foraminifera, and small shell fragments, among which bits of Echinoderm shell are numerous; there are many sponge spicules, but not much *Inoceramus* debris. One or two small grains of glauconite occur, and the specimen must have come from the base of the zone, the structure being like that of the *H. planus* zone.

The slide which differs from the other three is labelled M. 72*a*. It contains very few spicules and a larger number of *Inoceramus* prisms, as well as many irregular fragments of shell, the derivation of which it is difficult to recognize. In this respect it resembles two other pebbles which will be mentioned hereafter.

Pebbles not previously cut.—Six of these have been sliced and mounted by Mr. Hill, but one of them turns out to be of some other kind of limestone, not a Cretaceous chalk, and two others are so much perforated (Nos. 17 and 25) as to be of little use. The following are brief descriptions of the microscopical structure of the five chalk-pebbles.

No. 58. This is a compact chalk, the matrix of which is nearly as full of recognizable organic fragments as the chalk of the *H. planus* zone. There are plenty of cells, spheres, and small shell fragments, some of which appear to be broken and eroded *Inoceramus* prisms, but there is little Echinoderm debris and very few Foraminifera or sponge spicules. Of the larger fragments the most conspicuous are pieces of Polyzoa, some of them being unusually large, while many of the smaller and irregular shelly fragments are probably Polyzoan remains.

No. 41. This resembles the above and has about the same variety of contents. The included fragments are mostly small, consisting of spheres and small shell fragments with a few small *Textularia* and *Globigerina*. There are two or three pieces of *Inoceramus* shell showing prismatic structure and some isolated prisms; also some pieces of Echinoderm plates and many fragments of Polyzoan zoaria, but of sponge spicules there are very few.

No. 35. This has a larger proportion of amorphous matrix with scattered spheres and cells and a fair number of sponge spicules, but not many *Inoceramus* prisms. Small Foraminifera are numerous with some of larger size. The larger fragments are mostly pieces of Polyzoa and fragments of Echinoderms are scarce.

No. 25. This is a similar chalk to the last, but the slice is small, and the area of original material is so limited, from the extent of perforation, that little can be said of it except that sponge spicules and Foraminifera are numerous.

No. 17. This has been so much perforated that only small portions of the original rock remain. It was a chalk of the same compact kind, the proportion of amorphous matrix being large and all the recognizable particles small. There are several *Textularia* and a few shell fragments.

The first two of these slides (Nos. 41 and 58) and that of M. 72*a* may be considered together, as they consist of similar material, but it is on the first two that we must rely for comparative purposes, because the slice of 72*a* is a small one. In these two slides the number of fragments of the cellular zoaria of Polyzoa is a conspicuous feature which cannot be exactly matched by any chalk known to Mr. Hill or myself. But if the presence of these fragments is left out of account the enclosing material is comparable with the chalk of two different horizons in Devon and Dorset. These are the higher beds of the zone of *Rhynchonella Cuvieri* and certain rocky beds in the zone of *M. cortestudinarium*.

Until we had examined slides cut from the hard nodular beds in the higher part of the *R. Cuvieri* zone at Beer Harbour neither Mr. Hill nor I was aware that they possessed special characters and were so similar in composition to beds of a much higher horizon, i.e. to certain beds of hard chalk-limestone which occur in the zone of *M. cortestudinarium*, (1) at Annis Knob above Beer Harbour, (2) at Cruxton, near Maiden Newton, and (3) near Notton in the same neighbourhood. The general composition of the two sets of beds is the same, there being nearly the same proportion of cells and spheres distributed through the matrix, with a relatively small number of fragments derived from Inocerami or Echinoderms. Both contain many Foraminifera and a variable number of sponge spicules, and neither includes any glauconite grains.

The differences are that in the rock-beds of the *cortestudinarium* zone there is generally a larger number of the minute cavities left by the dissolution of siliceous spicules, that the Foraminifera are in rather greater number and variety, and that there is a larger proportion of small shelly particles in the matrix, exhibiting much variety of outline as if derived from several different kinds of organisms. On the other hand, the *Cuvieri* beds generally contain spherical areas, filled with amorphous matrix, which represent the spaces once occupied by Radiolaria, while in the higher zone such spheres are absent or very rare.

It should also be mentioned that the ordinary chalk of both zones has a much less variety of contents, that of the *Cuvieri* zone generally containing much *Inoceramus* debris but few spicules, while in the *cortestudinarium* zone the reverse is the case. Moreover, in the latter there is generally a larger proportion of amorphous matrix with fewer cells and spheres. It is only in the hard rocky layers occurring in that zone in Dorset and Devon that cells and spheres are so abundant.

When the slices cut from the pebbles 41, 58, and 72*a* are compared with those above-mentioned it is seen that they bear a rather greater resemblance to those from the beds in the *Cuvieri* zone than to those from the *cortestudinarium* zone. They differ, however, from the former in the absence of any traces of Radiolaria, and also of course (as previously mentioned) in the presence of large fragments of Polyzoan zoaria. It is possible that these two points of difference explain one another, and that the chalk of the pebbles was formed in a locality where Polyzoa were abundant and Radiolaria did not exist, while a little further north the conditions were unfavourable for Polyzoa but lay in the track of a current carrying Radiolaria.

The only true chalk which I have found to contain much debris of Polyzoa is a bed of yellowish rocky chalk forming the base of the *Cuvieri* zone in a quarry near Branscombe Church between Sidmouth and Beer. This bed differs from the basement bed seen in the cliffs by the absence of quartz and glauconite grains, its general composition resembling that of the pebbles 41 and 58 and including several fragments of Polyzoan framework, but it differs in containing a much larger quantity of *Inoceramus* debris and in the greater abundance of large sponge spicules, as well as by including many casts of Radiolaria.

The pebbles have no resemblance to the 'Beer Stone', which is a coarse shelly limestone composed mainly of fragments of *Inoceramus* shell, nor to the beds which overlie that stone in Beer Quarries, which are all very shelly, even the highest compact rock-bed being full of *Inoceramus* and Echinoderm fragments.

Pebble 35 differs from the others in having a much larger proportion of amorphous matrix, with fewer cells and spheres and a greater number of sponge spicules. There is, moreover, a greater number of Foraminifera and more variety of small shelly fragments. In all these respects it more nearly resembles the ordinary nodular chalk of the *cortestudinarium* zone, but it contains in addition fragments of a cellular skeleton like that of Polyzoa.

The pebbles 17 and 25, so far as the characters of the component chalk can be discerned in the small areas which remain, are of similar material to 35, and the fact of their being so riddled with the cavities made by boring animals points to their having consisted of a less hard kind of chalk, and is consistent with their attribution to the ordinary tough chalk of the *cortestudinarium* zone.

From the preceding descriptions and comparisons it will be seen that the pebbles of hard chalk which have been obtained by the Marine Biological Association from the floor of the English Channel seem to be referable to hard beds in the zones of *R. Cuvieri*, *Holaster planus*, and *Micraster cortestudinarium*. This is really what might have been expected from a consideration of the component beds of the Chalk in Devon and Dorset, the most persistent hard beds in these counties being found in the zones above-mentioned.

It is not surprising that nothing like the Melbourn Rock can be recognized among the pebbles, because in its typical aspect it does not reach so far west as Devonshire; neither ought we to expect anything exactly like the Beer Stone to occur among them, for that is entirely a local development even in Devonshire, as it only occurs between Beer and Branscombe on the coast and again at Sutton Barton, near Offwell, 6 miles to the north. Hence the Beer Stone must have been accumulated as a bank of shell-sand little more than a mile in width, but possibly 8 or 10 miles long from north to south. Lastly, it is not surprising that chalk formed 60 or 70 miles farther south should possess some peculiar and special features of its own.

The identification of these chalk-pebbles with beds occurring in the zones above-mentioned raises some interesting questions. If they have been derived from the destruction of chalk in situ we may infer that the Turonian and Senonian deposits extended southwards across the whole of South Devon and the adjacent Channel area as far south as lat. 49·50, which is about that of Valognes, in Normandy. We have then to ask whether the Cenomanian and Selbornian deposits which underlie the Turonian in Devonshire are likely to have had a similar extension.

Mr. Worth has assumed that the deposits from which the pebbles were derived did occur within the area in question, and I think he is justified in the assumption, but it may be well to give reasons for this belief. Such a varied assortment of pebbles, if transported to their present position, could only have been carried there in one of two ways; either by rivers flowing over a land surface or by floating ice.

These pebbles lie on the northern slope of the Channel floor, not in a depression which might be regarded as a portion of a submerged river valley (see Map, p. 63). The only large river which is likely to have brought them would be a continuation of the Tamar and Tavy, and such a river may have existed in Eocene times, or might in Miocene time have obtained them from Eocene gravels. Now ancient gravels which are possibly of Eocene age do occur on Cattedown, near Plymouth, and have yielded a piece of Lias limestone but no chalk-pebbles; neither do such pebbles occur in the other Tertiary gravels of Devonshire, so that this source is improbable.

That they should have been transported by floating ice during the Glacial epoch seems still more unlikely, for chalk-pebbles could not have been picked up along the shores of Cornwall or Devon, nor from those of Brittany. We should have to suppose a drift of ice from the east bringing stones from Normandy or from Dorset; but from these localities we should expect the debris of various Jurassic limestones which do not occur.

The assemblage of sedimentary rocks indicated by the pebbles is, in fact, just that which would be likely to coexist on the ground: it points to the superposition of Cretaceous deposits on Lias, Trias, and Permian, which is just the actual superposition in Devonshire. I agree therefore with Mr. Worth in regarding these pebbles as relics of formations which extended into the area of the Channel between Cornwall and Brittany, and as evidence on the strength of which we may discuss the probable extension of the several stages which appear to be represented.

The Selbornian Sands, which are only about 100 feet thick near Sidmouth, may have thinned out in a distance of 70 miles and in the direction of a land-surface; or they may have passed into soft and easily destroyed sands without cherts or hard calcareous beds. It is quite possible, however, that some of the so-called *flints* which Mr. Worth describes as the commonest kind of pebble on the Channel floor may really be *cherts*. This is particularly probable in the case of those which contain grains of quartz and glauconite, as in 62*b*, which was specially described by Mr. Worth, for such grains are rarely found in the flints of Turonian or Senonian Chalk.

The Cenomanian of Devonshire is of small thickness (from 3 to 18 feet) and consists of quartziferous limestones which indicate a proximity to land, though this land may have been an island on the site of Dartmoor. The persistence of Cenomanian deposits through Normandy makes it very likely that they continued for a considerable distance farther west, but only in the form of soft sands, which, however, may have contained cherts. The absence of any pebbles comparable with the hard quartziferous limestones of Devonshire makes it probable that if the Cenomanian did extend into the area in question its deposits were of the French and not the English type.

That the whole of the Turonian stage extended into this part of the Channel area is very probable, though it cannot yet be said that the pebbles afford positive evidence of it, because none of them are quite identical with any Turonian chalks in Devon or Dorset. If Nos. 41, 58, and 72*a* were really derived from the zone of *R. Cuvieri*, the assemblage of organisms prevailing at that time in the Turonian sea south of lat. 50 was not quite the same as that living in the area to the north; for Polyzoa were abundant and Radiolaria were absent or rare, while the reverse was the case to the northward.

The most important and at the same time the most indubitable identification is that of the Chalk Rock, for its discovery proves that at the epoch of its formation the conditions in this southern area were the same as those prevailing throughout the South of England. Incidentally also it makes it nearly certain that the higher part of the Turonian, i.e. the zone of *Terebratulina lata*, had a similar extension, because the epoch of the *planus* zone is believed to have been one of upheaval, and consequently the existence of Chalk Rock in its normal aspect implies the previous formation of some equivalent of the *T. lata* zone.

That the zone of *H. planus* should be followed by that of *M. cortestudinarium* is only natural, and if a larger number of the pebbles were examined fragments of some of the rocky beds of this zone might perhaps be more certainly recognized. In those which do appear to belong to this zone it is interesting to find that remains of Polyzoa are again a conspicuous feature.

It is to be hoped that the Marine Biological Association will continue the work of exploring the floor of the Channel and will recover pebbles from positions still farther south and west, for it can hardly be doubted that they have a wider distribution in those directions than has yet been ascertained. Actual evidence of this and farther investigation of the flints and cherts would be very desirable.

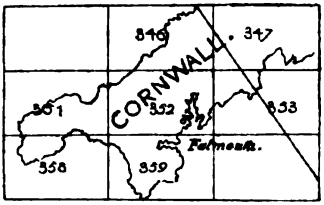
IV.—On the General Geological Structure of Western Cornwall, with a Note on the Porthluney–Dodman Section.

By Upfield Green and C. Davies Sherborn.

In attempting an explanation of the structure of Western Cornwall it seems fairly evident that the first step should be a study of the coast sections, for the interior of the country is so folded and buckled that it is quite bewildering in its complexity. The natural sections most useful for this purpose are those of Black Head to Gorran Haven, St. Michael Carhayes to the Dodman, Falmouth to the Manacles, and Trewavas to Mullion, since all these sections cross the lines of strike more or less at right angles. It soon becomes abundantly clear that the complexity of folding exhibited by the rocks is but the detail of greater movements and need not seriously detain us. In 1908 Upfield Green expressed our views on those greater movements in the ninety-fifth report of the Trans. Roy. Geol. Soc. Cornwall, and endeavoured to show that the great Hercynian movements had involved Cornwall, throwing the country into three east and west anticlinals with sinuous outcrops, which anticlinals had gradually been forced over to the north into overfolds. These folds have been further complicated, distorted, and confused by local minor bucklings shown by the strata on every side. In the paper quoted a map was given showing the major anticlinals, and one section across the country from Newquay to Portholland was added to explain our views on the subsequent overfolding of these anticlinals to the north. In December, 1912, we jointly published a note on the Trewavas–Mullion section, which we had written in May, 1910, and this second section corresponded in a striking manner with our first from Newquay to Portholland.

For the purpose of clearing up our views on Cornwall it is necessary to publish a third section, that from Porthluney to the Dodman, for this fits on to the southern end of Green's Newquay to Portholland section, and completes it for 2½ miles further south.

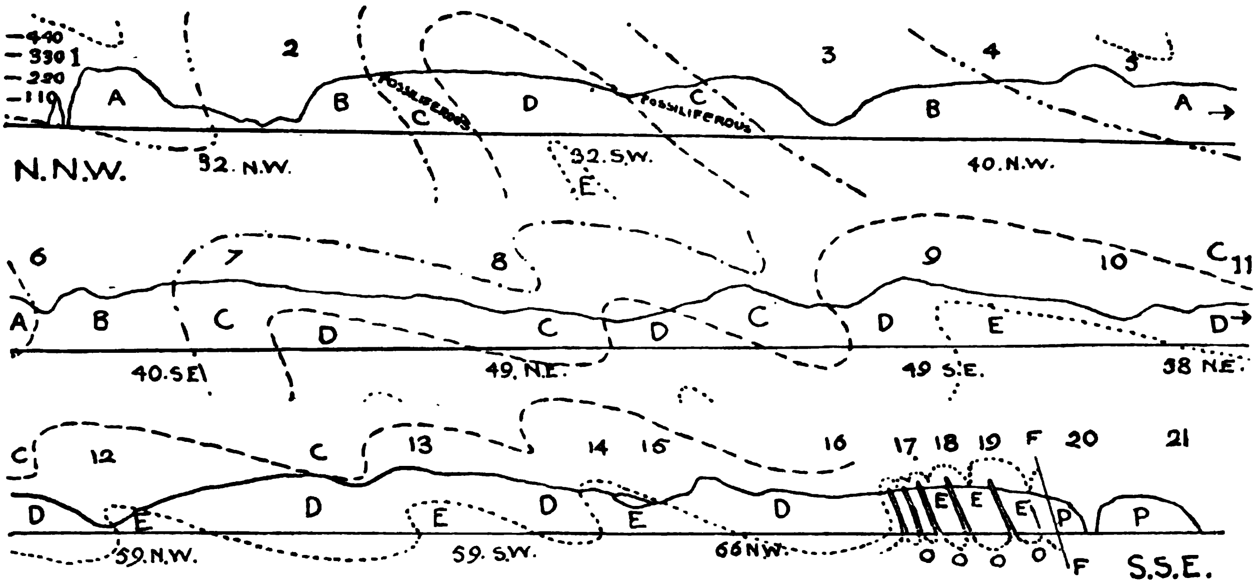
For facility of reference it will be necessary to examine the following sheets of the new series Geological Survey map of England and Wales, as it is obviously impossible to reproduce such a map in this Magazine.



Key-map to sheets of Geological Survey Map.

This map agrees so closely in mapping with the results of our own twenty years observations and is so confirmatory of our views that we may well refer to it. The one serious error is the line of 'conglomerate' dividing the 'Grampound Grit' and the 'Porthscatho Beds' almost at right angles to their strike on Sheet 353. But as those two deposits are one and the same, this obvious error need not detain us.

At the foot of Sheet 353 is a section from Porthluney to the Dodman, and this section will suffice precisely for our purpose. We accept it, for it corresponds with our own observations, although we place our own interpretation upon it. It will be noted that there are several exposures of quartzite. These are the quartzites that have yielded Ordovician fossils at Gorran, Diamond Point (Porthluney), and Carne, and upon the age of which every observer is agreed. The bands are definite although broken up, pushed about, and dismembered, and can be traced from Gorran through Porthluney to Carne and are seen again westwards at Nare Point (Helford River) and thence across the country to Cury, north-east of Mullion. This quartzite is the oldest stratified deposit in Cornwall, except perhaps the Dodman phyllites and the Lizard rocks, with which we are acquainted, and we have never seen the bed upon which it rests, unless the peculiar greenish-black quartzite containing *Orthis calligramma* (Brit. Mus. and Mus. Pract. Geol.), occasionally seen as boulders in and near Catasuent Cove, may represent a lower bed. Now let us interpret this section. To the north, at a point marked Porthluney, is a little canal cut to drain the Carhayes Lake. A low cliff borders the eastern side of the canal composed entirely of Porthscatho Beds, though we believe the first few yards of the northern end show Veryan Beds at the base of the cliff. Passing out of the canal and proceeding south along the beach, we encounter the coarse 'basal conglomerate' of the Porthscatho Beds, followed by a mass of igneous rock (marked D) which has broken through and disturbed the beds. At this point the interest begins, for we find undoubted Veryan Beds beyond the igneous intrusion, containing lenticles of fossiliferous Silurian rocks and continuing unaltered south to the further horn of Catasuent Cove. Beyond Catasuent Cove the coast for three-quarters of a mile is inaccessible to us,



Generalized Section across Cornwall from Trerathick Point (N.) to the Dodman (S.). By Upfield Green and C. Davies Sherborn. 1 : 63,360; 1 inch = 1 mile; 1 inch = 880 feet.

A. Staddon = Coblenzian.
B. Meadfoot = Taunusian.
C. Falmouth, D. Porthscatho, E. Veryan } Gedinnian = Lower Devonian.
O. Ordovician quartzites.
P. Phyllites of the Dodman.

1, Trerathic Point; 2, stream; 3, stream; 4, Bosoughan Road; 5, railway; 6, stream; 7, road; 8, millpond; 9, Grampound Road Railway; 10, stream; 11, road at Barteliver Quarry; 12, River Fal and Old Halebote Quarry; 13, Pencoose; 14, Polgrain; 15, road and stream; 16, Portholland and Porthluney; 17, Catasuent Cove; 18, Greeb Point; 19, The Clitters; 20, Hemmich Beach; 21, The Dodman. The "32 N.W.", etc., indicate the sheets of the six inch map.

but we are quite satisfied from our knowledge of the land surface with the Survey section on which we base these remarks and accept it all as coloured, namely 'Veryan', up to the Dodman phyllites, recognizing that it would be progressively altered by compression as it was crushed and forced against the Dodman mass. Now it is clear that these Veryan Beds are interrupted here and there by quartzites which contain Ordovician fossils, and it is equally clear from the ground, the mapping, and the section that these quartzites appear at intervals up to the mass called 'The Clitters'. They represent in our judgment the crushed and broken anticlinal folds of a once continuous bed, the synclinals of which are filled with Veryan Beds more and more altered as we pass south till they are brought up short against the Dodman mass, which may be considered to be of earlier age and part of the old ridge of rocks represented on the west by the Lizard area.

Having now given our views on this section we may briefly sketch the general structure of the country, using the Survey maps as our illustration. The order of succession of the sedimentary rocks from above downwards is Meadfoot, Falmouth, Porthscatho, Veryan, Quartzites, as stated and defined in Geol. Mag., December, 1912, p. 560. All these beds fan out as we proceed westwards, and the broad edge of the Porthscatho Beds is altered by the granite mass which comes in contact with it into the 'Mylor Beds' of the Survey. It is clear, therefore, that the 'Mylor Beds' have little claim for separate recognition. The beds, originally horizontal, were forced into anticlinals, then into overfolds, and finally crammed and crushed into the endless minor contortions so puzzling in the field. But they have yet retained their original sequence, and, though once present, some Silurian rocks have disappeared in the smash, and fragments of the Ludlow, Wenlock, and Woolhope Beds still remain as lenticles of fossiliferous limestone in the Lower Devonian beds of Perhaver, Porthluney, Veryan, Porthalla, and Mullion. From *all* of these places we have no doubt recognizable Silurian fossils will eventually be found to offer further support to these opinions.[1]

V.—The Upper Trias of Leicestershire.

By A. R. Horwood.

3. Stratigraphy (*continued*).

(WITH A TEXT-MAP.)

(*Continued from p.* 32.)

(2) *Measham and Orton District.*

THIS district is bounded on the north by the Coalville and Ashby line, on the west and south by the county boundaries, on the east by the Shackerstone and Market Bosworth lines. In the north are exposures of Coal-measures, Permian breccias, and Bunter, which the Trias in turn rests upon unconformably. The Lower Keuper

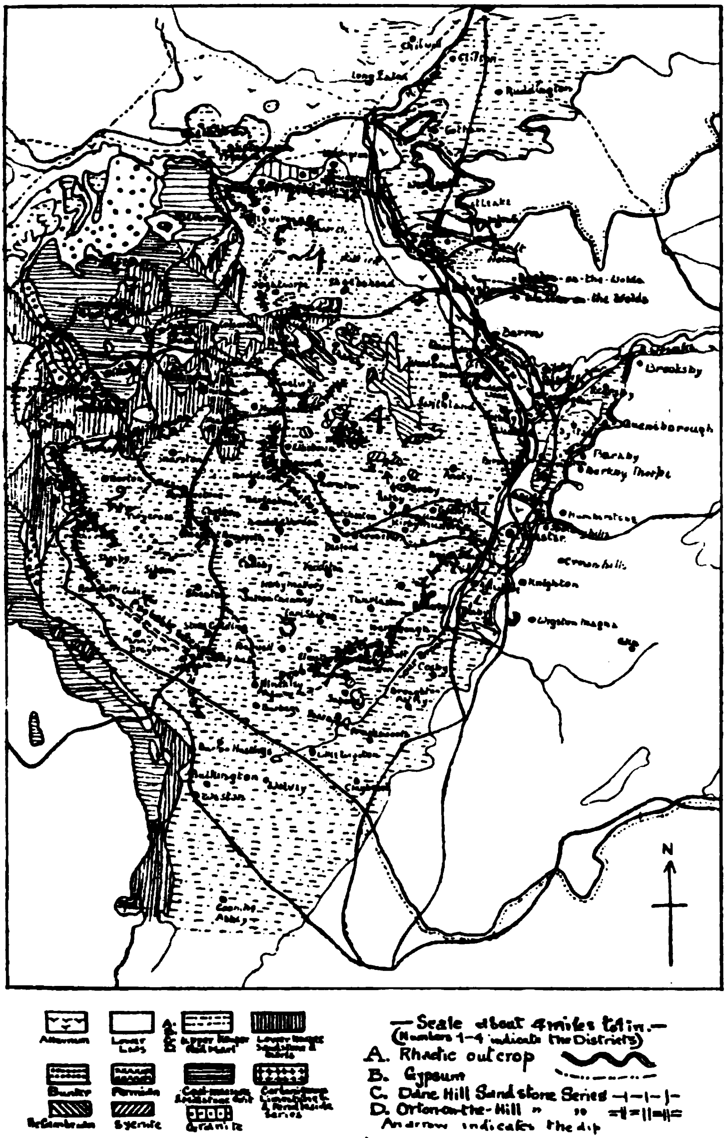
[1] [When staying at Mullion, Cornwall, in 1906, I found a perfectly recognizable trilobite when going down the path to Pollurian Cove, but its importance escaped me, and I did not preserve it, much to my regret.—H. Woodward.]

forms a long tract on the west not more than two miles in breadth, forming a good feature, the sandstones giving rise to scarps, whilst the Red Marl occupies the rest of the district to the east. On the south-west beds of sandstone form marked features, which also give rise to bold escarpments, whilst the Red Marl itself constitutes a uniform plateau with little or no variation in heights. There are few exposures in the marls, which on the extreme east are covered by a mantle of Boulder-clay and sands. The River Sence and the Sence Brook, however, cut down to the lower parts of the Red Marl, and a good deal of alluvium fills the valleys to the south. The altitude over most of this ground rises uniformly above 300 feet, and in some parts to over 400, rarely sinking below 250. A ridge of hills is formed by the Orton Sandstone striking north-west and south-east, and another ridge meets it at right angles from Market Bosworth.

The surface of the Bunter was apparently much eroded before the deposition of the Lower Keuper which lies in hollows of the pebble beds, and abuts the ridges unconformably. Both the Red Marl and Lower Keuper Sandstone respectively overlap the Bunter, and the former the latter in this district. There is a noticeable thinning out of the Bunter from west to east, and also of the Lower Keuper Sandstone. The Red Marl seems to thicken in this direction, however. The pre-Triassic surface in this area (and No. 3, to which the following remarks also apply) shows that Trias rests on rocks older than the Coal-measures in many places, indicating concealed ridges of Charnian and Cambrian beds between Warwickshire and Charnwood Forest. In this way we should expect to find evidence of undulation in the overlying strata and of flexures, but they are not clearly indicated unless it be where the sandstones about Orton crop out and give rise to a series of sinuous outcrops. Molyneux noticed years ago in the neighbourhood of Burton-on-Trent the undulatory bedding of the Red Marl in that direction, so that there are probably similar features hitherto unrevealed in this area. The existence of strain shadows in the grits and quartzites of the Permian breccias of this district, as Brown suggested, indicates their derivation from folded rocks.

Borings at Sapcote Freeholt and Elmesthorpe and at Market Bosworth reveal the presence of Cambrian rocks similar to the Nuneaton Series, so that a ridge striking north-west and south-east extends between that point and Charnwood Forest, cutting out the Coal-measures which over this area were deposited only in little shallow basins as at Elmesthorpe and to the south-east and north-west of Rugby. The existence of Stockingford Shales at Crown Hill, as proved in the boring at 800 odd feet, shows that another ridge sets in in that direction, and probably the syenites of Croft, Enderby, etc., are intrusive through the same beds. They moreover overlie a south-easterly extension of the pre-Cambrian rocks of Charnwood Forest, which extend southwards as far as Orton and Bletchley, if not further south. Thus both pre-Triassic and Triassic rocks south and south-east of Charnwood Forest are like the Coal-measures banked against ridges of Charnian or Nuneaton older rocks, or deposited in hollows in their numerous ramifications.

SKETCH-MAP OF WEST LEICESTERSHIRE, SHOWING THE UPPER TRIAS AND ASSOCIATED FORMATIONS WITH SANDSTONE AND GYPSUM OUTCROPS.



Photographed by A. Newton from a sketch-map of the Upper Trias of Leicestershire to show the general outlines of the district and the localities referred to in the text.

The Bunter beds seem to die out in the neighbourhood of Market Bosworth, being proved in the King's Hill boring. The age of the movements causing these foldings parallel with the Charnwood and Nuneaton ridges is post-Carboniferous, for both the older rocks and the Coal-measures are affected. Moreover, the latter were greatly denuded before the Permian breccias were deposited. The latter, too, are not influenced by these folds, so that they must be, as Browne states, pre-Permian. In this area the Lower Keuper sandstones rarely exceed 150 feet, and they thin out to the east. They resemble the beds in District (1), consisting of sandstones with marly beds between.

In the north-west the sandstones form high ground, making a ridge from Measham to Willesley. At Willesley this ridge rises to 450 feet, running north and south, and the sandstones crop out. At the south end of the Park they terminate abruptly, the Coal-measures being faulted up against them and the Permian breccias below, but the fault is overlapped by the two later beds. From here to Measham the Lower Keuper forms a good feature further east.

Further south in the Mease Valley a boring at Coton Park Colliery (250 O.D.) showed the Lower Keuper Sandstone to be 63 feet thick, overlying 228 feet of Bunter. At Netherseal, north of the River Mease, the outcrop bifurcates, striking west, and is cut out by a fault at Gunby Lea (south-west by north-east). At the Colliery it is obscured by Boulder-clay, but in the No. 1 boring Trias and Permian to a depth of 263 ft. 6 in. were pierced 1,000 yards south-east of Grange Wood House (256 O.D.). To the north-west at Caldwell the sandstone is predominant, massive beds with marly partings dipping south-west at 5 degrees being cut through in the colliery branch-line.

At Stretton-en-le-Field, east of the River Mease, in a boring at Saltersford, 2 feet of Marl under 9 feet of sand and gravel overlaid drab rock and brown bind, etc., and in another boring 10 feet of soil, sand, and gravel overlaid 18 ft. 1 in. of Red Marl and brown and grey rock.

Southward in the Chilcote boring (270 O.D.) the Trias was 704 feet thick, there being 600 feet of Bunter with twenty-one beds of conglomerate or red sandstone with pebbles and 70 feet of Lower Keuper Sandstone (or 100 feet perhaps), with 30 feet of Permian breccia overlying 300 feet of Coal-measures with no coal-seams. At Appleby No. 1 boring, White House, 578 feet of Trias, with probably some Permian, overlaid 396 feet of Coal-measures. The second boring at Bird's Gorse, Side Hollows, appears to have passed through 110 ft. 9 in. Lower Keuper sandstones and marls, 333 ft. 9½ in. Bunter, lying over Coal-measures with coals. A third boring at Appleby Hall, near Roe House, passed through 154 ft. 3 in. marls with gypsum and 455 ft. 3 in. of sandy beds without pebbles, some of which as in the other borings may be Permian and the rest Bunter. The Bunter thus thins out and becomes abnormal within a very short interval. About Measham it is overlapped by the Lower Keuper sandstones, which crop out in the brickyards to the east of the station. In one place 4 feet of Lower Keuper Sandstone is seen to overlie

Permian beds at this point. East of Measham it forms a broad outcrop, however, and both marls and sandstones are distinguishable, whilst towards Willesley it forms a striking ridge. The general dip is to the south.

Borings at Snarestone (310 O.D.) show 80 feet Lower Keuper Sandstone, 47 feet Bunter, and 96 feet of Permian, above Coal-measures. In No. 1 boring there was 45 feet of Lower Keuper, 70 feet Bunter, 38 ft. 6 in. Permian, and in No. 2 on the Bosworth Road, near the aqueduct, 78 ft. 9 in. Lower Keuper, 121 ft. 3 in. Bunter, overlying Coal-measures. East of the River Mease the Lower Keuper sandstones and marls here extend in a ridge to Normanton, flanking the Mease on the opposite side of the Willesley ridge. This ridge extends to Swepstone, and northward to the Burton line at Breach Hill, where they repose directly on Coal-measures in the cutting, no Permian beds intervening. Along this ridge the sandstones crop out and towards Normanton rise to an altitude of over 450 feet. To the east they are covered by Red Marl, the outcrop diminishing around the Altons.

At Packington, the most easterly occurrence of Permian breccias, unconsolidated and containing slate fragments, waterstones overlie and overlap the breccias. At Hugglescote (514 O.D.) a boring showed soil and clay 1 ft. 6 in., marl and sandstone 200 ft. 3 in., of which 96 ft. 11 in. is probably in Red Marl. There was here no conglomerate at the base of the Lower Keuper, but a pink mixture overlies Coal-measures. In the brickyard at Heather a section formerly showed 37 feet of Keuper Sandstone overlying 1 foot of conglomerate and Coal-measures. In the south-east there was more sandstone. The upper beds were found to pass gradually into marl, making their junction doubtful. In the Colliery it was shown that there was an extension of the Cole Orton fault, of 20 – 25 yards, bringing the Lower Keuper Sandstone down close to the stream. Outside this area the Lullington boring (275 O.D.) passed through 1,190 feet of Trias, with probably some thickness of Permian and Upper Coal-measures in the lower 547 feet underlying a doubtful thickness of Bunter of unusual type. Above this there was apparently 155 feet Lower Keuper sandstones and marls and 488 feet of Red Marl. These thicknesses are only approximate, since the limits of each division are in this area difficult to define. This is especially so in the case of the Red Marl, the boundary of which with the Lower Keuper between No Man's Heath and Appleby and Astrey to the south is not clear, though beds of sandstone in the Lower Keuper alternate with the marls, and to the east the Red Marl makes a feature which enables a boundary to be fixed between the Upper and Lower Marls, the latter predominating here. In the direction of Shuttington the outcrop widens and there are some sandstone horizons, which are traceable for some distance, though they ultimately die out, and the ground resumes a typical Red Marl appearance, though it is heavier than the latter. These flaggy beds are exposed around Astrey, and in the stream sections show a passage from the sandstones and marls into the Red Marl. This was noticed by Howell years ago. To the south at

Warton thick sandstones, which have been quarried for building, dip at 9 degrees, being influenced by the boundary fault, but eastward they are more horizontal. The same thick building stones crop out at Newton Regis and Seckington.

At Dordon Hall Trias Sandstones and Coal-measures are seen on either side of the road faulted into this position by the Polesworth fault, which here strikes north. The Red Marl in this district exhibits little or no variation except where sandstone features are developed. A skerry band near the top is discernible, but is seldom exposed and cannot be traced over any distance. Another not far from the base of the waterstones in this region makes a feature where it thickens out into a more massive sandstone. There are some thin gypsum bands towards the base, but they are of no importance. It is only in the valleys that the Red Marl affords any exposures of any extent apart from the hard bands. There are no brickyards affording sections that throw any light on the stratigraphy, so that it is necessary to rely on borings for a knowledge of the deeper geology of this region.

The sandstones that are so massive about Orton-on-the-Hill thin out towards Appleby Parva, where they are seen to the south, and at No Man's Heath they thicken and are divisible into two bands showing marked flexures. These are continuous southward between Astrey and Norton, where a third band comes on above these which thickens to a broad outcrop with a sinuous contour at Little Orton. Just south of this a fourth band crops out below these three. Between Twycross and Orton-on-the-Hill there are five or six bands which thicken considerably and run in a north and south direction in a more or less parallel manner with similar undulatory contours. The sandstones give a marked character to the scenery, the hard and soft bands (of marl) alternating and forming diversified country. They can be traced southward to Sheepy Magna, where they are cut off by the valley of the River Sence, and are not traceable south of this point. But, as remarked by Howell, "there are numerous thin bands of greenish-white micaceous sandstone (called 'skerries' by the miners) throughout the whole of the marl, and it is probable that the beds at Orton Hill are formed by a local thickening of some of these bands, for they lie at a much lower horizon than those mentioned by Sir Roderick Murchison and Mr. Strickland between Henley-in-Arden and Warwick, presently to be described." These sandstones are feebly represented around Shackerstone and Carlton Bridge (see district 3). They are ripple-marked and have been used in situ as threshing-floors. They were said by Coleman to be only 1 yard thick, but, as remarked by Howell, they reach a thickness of 20–30 feet, and are probably represented in the boring at Lindley Hall (*supra*) by a bed of sandstone near the base 18 feet thick which is red in colour. That at Orton is mainly white, which is probably due to weathering.

In the northern part there are numerous beds of white sandstone in the Red Marl, as proved in borings at Snibstone (No. 1) (510 O.D.), where 166 ft. 7 in. of Red Marl overlies 21 ft. 9 in. of dolerite, with 7 feet white sandstone at 79 ft. 6 in., 3 ft. 6 in. at 104 ft. 6 in., 5 feet at 110 ft. 6 in., 3 feet at 143 ft. 10 in., 2 feet at 156 ft. 7 in., 4 ft. 2 in. at 161 ft. 5 in. In the boring at No. 2 (510 O.D.) 179 feet of Red Marl overlies the Coal-measures with twelve bands of white and brown sandstone from 3 to 11 feet thick and a white conglomerate 1 ft. 6 in. at 159 feet. At Hugglescote 201 ft. 9 in. Red Marl overlies Coal-measures (at 514 O.D.), and there are five beds of brown or white sandstone from 2 to 12 feet thick. Probably, as these beds are not far from the base of the Red Marl, and Lower Keuper Sandstone underlies them in borings to the east with a basal conglomerate, they represent some of the beds seen at the surface at Orton.

To the south, at Market Bosworth, several borings have been made which give some idea of the thickness of the Red Marl and the extent of the Lower Keuper sandstones and marls in this district. At the Bosworth Wharf boring at the railway station (300 O.D.) the section was Drift 10 feet, Keuper Marl 332 feet, Lower Keuper Sandstone 219 feet, Bunter 178 feet, Breccia 10 feet, overlying Cambrian rocks. In the Red Marl there are no sandstone beds of importance, but in the Lower Keuper Sandstone two beds, each 18 feet thick, represent those seen at the surface on the west. In the Kingshill Spinney boring (300 O.D.) there was 126 feet Drift, 246 feet Keuper Marl, 322 feet of Keuper Sandstone, 124 feet Bunter, and a Breccia 30 feet overlying 206 feet Stockingford Shales. The above is from Mr. Plant's MSS. He regarded the 206 feet Stockingford Shales as Carboniferous rocks. Professor H. Browne considered the whole 1,030 feet as Trias. The lower part, he says, was in coarse sandstone with rounded pebbles, evidently Bunter conglomerates, and he considers this fixes their easterly limit in this region. To the north-east of Charnwood Forest they are developed much further east, however. It is probable the thickness assigned to the Lower Keuper is excessive and that half of this may be Bunter Sandstone.

The boring at Cow Pasture, 800 yards north-east of the church (380 O.D.), as given by Mr. Plant and corrected by Professor Brown, is as follows:—

	feet.
Boulder-clay	40
Red Marl and sandstone	299
Bunter [?] Sandstone	39
Breccia	50
Stockingford Shales	119
	547

At 500 feet an igneous rock was met with. The Trias here has thinned out considerably as it approaches the pre-Carboniferous ridge. At Lindley Hall in the extreme south 660 feet of Trias were pierced, some of which, at the base, were probably Lower Keuper Sandstone.

Since the Orton Sandstone forms so distinct a feature locally and is probably to be correlated with the Castle Donington, Kegworth, and Diseworth Beds in the Red Marl, we propose to give them this name, *Orton-on-the-Hill Sandstone Group*, to distinguish them from those at a higher horizon in the Red Marl at Dane Hills, Croft, Narborough, and elsewhere.

(3) *Hinckley and Croft District.*

The best boundary for this uniform tract of Red Marl, with intrusive knolls of syenite in the south-east, is on the west the Shackerstone line, on the south the Watling Street, on the east the Leicester and Rugby branch of the Midland Railway, and its Burton and Leicester branch on the north, with the West Bridge line. It is in this area in the south that we have indications of the Upper Keuper Sandstone lying near the top of the series. In the extreme west south of Nailstone a wide tract of Boulder-clay obscures the Red Marl entirely, except just round Market Bosworth, to which reference has already been made. The eastern side is also much obscured by drift, but numerous streams have cut through this mantle and exposed the Red Marl in a series of ramifying branches north of the Soar Valley. To the south the River Soar has spread a wide tract of alluvium over the excavated Trias, and elsewhere it is covered by drift right up to the Liassic outcrop, and covers the Rhætics in the north-east corner except where quarrying has, as at the fine section at Glen Parva, exposed them. Owing to the existence of outliers of syenite, which rise up in dome-like masses forming isolated knolls, a good many sections in the Trias are accessible, and the relation of the Red Marl to the pre-Carboniferous floor can be studied with great advantage. Reference to the paper by Mr. Harrison on this subject will facilitate any observations on this head, and it is not intended to deal with this aspect here in any great detail. Though there are no exposures of Lower Keuper Sandstone in this district, borings for coal south of the Burton line have encountered a variable thickness of this member. At the South Leicestershire Colliery, just south of Bardon Hill, 178 ft. 11 in. of Red Marl and Sandstone were pierced with five beds of whitish sandstone varying from 2 to 9 feet in thickness. At No. 2 the Trias was 181 ft. 2 in. thick, and overlaid dolerite, as at Whitwick. At the Ibstock Old Pit (470 O.D.) 124 ft. 6 in. Red Marl and sandstones overlie a conglomerate or Crossil bed 2 feet thick. Five beds of sandstone 3 to 9 feet thick were encountered, some of this belonging to the Lower Keuper. At Ellistown Colliery (560 O.D.) there is a bed of skerry 6 feet thick at 205 feet, marl and skerry 10 feet at 245 ft. 9 in., which is probably the same as a bed 12 feet thick at Nailstone. This is perhaps equivalent to a skerry outcropping in District (4) at Botcheston, and in the Lindridge borings.

In the brickyard at Bagworth Station six green marly bands and a skerry 1 foot thick are exposed. Ripple-marks north 20 degrees west are frequent in the skerries, and are exceptionally deep. Pseudomorphs of salt crystals are frequent. As at Sileby and Bardon, vertical streaks of Green Marl, deltoid in shape, depend from below the Green Marl bands, chiefly from the top band, but here and there from others, but this does not occur in the Red Marl. In the Bagworth Colliery section (533 O.D.) 315 feet marls, skerries, and sandstone overlie a conglomerate 1 ft. 6 in. At 203 feet stone 20 ft. 6 in. was met with. This probably represents the Orton-on-the-Hill Sandstone. In the Bagworth new sinking (533 O.D.) 299 ft. 4 in. of Red Marl, sandstone, gypsum, and skerries overlie a conglomerate 2 feet thick.

There is a strong white sandstone 9 feet thick at 235 feet, and a stony sandstone 3 feet thick at 282 ft. 5 in. At Nailstone (500 O.D.) there were 180 feet Red Marls and skerries, light-blue sandstone rock 12 feet, marls and skerries 60 feet, conglomerate 5 feet thick, the lower part Lower Keuper.

The sandstone which is seen at the surface at Shackerstone and Carlton Bridge may represent the Orton-on-the-Hill Sandstone.

A boring at Newbold Verdon (400 O.D.) shows—

	ft.	in.
Sand and marl	57	0
Red Marl and gypsum	216	0
Grey rock, probably skerry	2	6
Marl and gypsum	21	6
Marl and sand	26	0
Grey rock	4	3
Pink and purple marl	15	3
Hard grey grozzly bed	17	6
Soft parting	0	6
Hard rock with red and blue partings	7	9
	368	3

The lowest 100 feet is probably in the Lower Keuper here.

In a boring at Stockshouse Farm, Peckleton (400 O.D.), 372 feet Keuper Marl and Sandstone overlaid 88 feet of Coal-measures, 12 feet Millstone Grit, 27 ft. 6 in. Carboniferous Limestone, and 37 ft. 6 in. of a rock resembling Warwickshire camptonite or diabase.

De Rance gives a section at Desford of 213 feet marl and 140 feet waterstones. At Desford No. 1 (400 O.D.) 256 ft. 3 in. of Red Marl, gypsum, sandstone, and skerries overlaid a conglomerate 6 feet thick. Three beds of sandstone 2–15 feet thick were encountered, the last (Lower Keuper) at 239 ft. 3 in.

Several borings were made at Lindridge, near Desford, nearer Bagworth. At No. 1 at 325 O.D., close to the lodge near Lindridge Hall, the section was given as—

	feet.
Drift	2
Upper Keuper Sandstone	20
Red Marl and gypsum	44
Lower Keuper Sandstone	204
Slaty Rocks, Red Marls, dipping at 70°	114
	384

De Rance gives this as at 400 O.D. and only gives 270 feet. At No. 2 in the south-west corner of a field south of the farm, 1 mile west of No. 1, 277 feet of Keuper Sandstone overlaid 10 ft. 9 in. blue bind, 9 inches stony bind and Coal-measures and five coals 100 feet thick. At the shaft, a quarter of a mile south-west of No. 1 (325 feet), the section was—

	ft.	in.
Upper Gypseous Series	50	2
Grey skerry	6	6
Lower Gypseous	86	10
Grey and red marly sandstone	114	6
Red Marl with limestone	18	0
Coal-measures and four seams	231	0
	507	0

Mr. Plant said he discovered a fine geode containing crystals of selenite in the Lower Keuper Sandstone in the sinking.

Considerations of water-supply necessitated the sinking of a deep well and a boring to the south at Hinckley, which have become rather notorious from the difficulties arising from the different advice tendered and the character of the boring and method adopted. James Plant had charge of the boring, acting as adviser, and his reasons for the choice of the site were somewhat as follows. The ground around Hinckley falls away into the valley on all sides, except on the north-west, where, after a slight depression, half a mile away it rises up to Wykin Hills, and the plateau continues to Crown Hill. The impermanent streams all flow from the town, and are fed at different levels by water from drift beds. He considered water-stones would be reached between 300 and 400 feet, and he stated they were developed most to the south-west, west, and north-west. He referred to a ridge between Hartshill and Charnwood, causing two basins, the western one being the one upon which Hinckley was situated, on its eastern border. As this western basin was deeper the water-stones he argued were thicker. He cited borings at Hawkesbury and Nuneaton, where from the waterstones in twenty-four hours one and a half million and a quarter of a million gallons of water were obtained from depths of 120 and 112 feet respectively. The boring showed in June, 1879, 150 feet Drift, 30 feet Upper Sandstones, 250 feet Red Marl and gypsum, 150 feet waterstones, and he considered the last were penetrated between 390 and 410 feet. Mr. Stooke, who was asked to take the matter in hand, stated at the Local Government Board inquiry, August 12, 1884, that he considered the waterstones were reached at 500 feet. He said the last vein of gypsum was at 526 feet, but he found traces of it down to 726 feet. This boring was 1 mile to south-west of Hinckley. He gives an account of it with a figure and section, in which below the Boulder-clay, 350 feet (down to 500 feet) of new Red Marl with veins of gypsum and beds of sandstone were encountered, then 200 feet of sandstone with nodules of gypsum and beds of marl, and 100 feet of waterstones (down to 800 feet), overlying Permian beds. This last is doubtful. Some confusion has been made here as to the term waterstones. The last 50 feet contained the best water, but it was much too full of mineral matter. It resembles the waters of Leamington, Cheltenham, and Shearsby, in Leicestershire, and its constituents were:—

	Grains in Imperial Gallon.
Chloride of sodium	71·2
Chloride of potassium	traces
Sulphate of soda	238·3
Sulphate of magnesia	8·0
Sulphate of lime	114·4
Carbonate of magnesia	22·3
Silica	1·4
	455·6

This means about sixty grains to the gallon more than the Shearsby water, which has been described as the Cheltenham of Leicestershire, and derives its properties from the Red Marl underlying the Lias Clays, through which it finds its way to the surface near the inn. The main difference lies in the absence of sulphate of lime in the Shearsby waters, which is accounted for by the strong smell of sulphuretted hydrogen it possesses, caused by the action of iron in the Lias on the gypsum. Mr. Stooke recommended to the Board in place of this site for a boring and supply of water a spot 5 miles from Hinckley, but in his paper refers to one 3½ miles south-west, near the White Stone, Attleborough, where the water was obtained from a well and heading in the waterstones. A section here shows 60 feet Trias, 70 feet Cambrian Shales, half-way between Chilvers Coton and Burton Hastings.

The whole district around Hinckley is much covered by Chalky Boulder-clay as far as Stapleton and Barwell, and no solid rocks outcrop anywhere in the district; so that it is only from borings that information hereabouts is available. The valley being 60 feet below the usual level one would nevertheless expect some beds to crop out. A pit to the west near the Watling Street is in Boulder-clay and Red Marls, but presents nothing of interest. A boring at Elmesthorpe[1] (300 O.D.) showed 68 feet Drift, 120 feet Keuper Marl, 330 feet Keuper Sandstone, 980 feet said by Plant to be Coal-measures, but Professor Brown gives the following reading:—

	ft.	in.
Upper Keuper Marls with gypsum .	470	0
Conglomerate or breccia . . .	a few in Cheshire	
Coal-measures	210	5
Stockingford Shales	974	0
	1654	5

He further found an outcrop of the Stockingford Shales on the Leicester and Birmingham line 1,450 yards east of the station, 2 miles north-east of the above boring, the shales being struck in a field on the north side of the line at a depth of 24 feet. He regards the Barrow Hill 'Greenstone' as a Warwickshire diorite, and thinks that the bosses of igneous rock at Sapcote, Enderby, and Croft are intrusions in the shales and associated rocks. It is possible the slate underlying the syenite in Marston's Pit, Enderby, not now visible, is not Swithland Slate but Stockingford Shale, to which it has some resemblance. The occurrence of the shales on the east of the River Soar, though at a great depth in the Crown Hill borings, would seem to favour this view.

These facts show how irregular and varied was the floor upon which the Trias was deposited, and how ancient were the peaks of intrusive rocks which appear here and there through this pre-Carboniferous floor.

At Stony Stanton, in the Bottom Pit, Keuper Marl lies in the hollows of the syenite nearer the church (south side). A rather decomposed mass of syenite forms a dome or saddle, and on either side the Red Marl with green bands fills the troughs abutting against the syenite with the green bands slightly upturned, in contact at the base, and for some distance into the Red Marl angular masses of syenite have been included. The Red Marl is of a densely

[1] This is the Sapcote Freeholt boring.

reddish-brown colour, flaky, and highly ferruginous, giving it a baked appearance. On the north side of the pit a deeper depression in the syenite is filled with chocolate marl with several light bands in a perfectly horizontal manner.

In the pit south of the church Keuper lies on the flat surface of the syenite. In the next pit, close to the Sapcote Road, Keuper Marl lies on the syenite to the north. There is near the base of the Red Marl here a thickish skerry band, which with the grey or green bands above dips at a considerable angle. This may be the equivalent of the Upper Keuper Sandstone at Narborough, Croft, and Enderby.

At Croft the Keuper Marl dips south-east away from the core of syenite at a high angle. There are two marked skerry bands divided by some twenty feet or more of marl. In one green band near the top the colour is splashed and runs down vertically into the Red Marl, as at Bardon Hill, where bands of green marl run down like ribbons vertically into the intervening Red Marl. The skerry grades from a greenish marly rock into a white sandstone 6–10 feet thick, slightly calcareous, with much garnet. At the base there is a breccia of Red Marl with rounded blocks of syenite at some distance, and these present an uneven pitted appearance.

Some of these fragments occur at a considerable height above the line of junction, deposited in bands of green marl. Where the red and green marl touch the line is often rippled and not perfectly even in hand-specimens. The Red Marl presents the baked appearance of beds seen at Star Brick Works, near the concretionary bed. The dip of the beds seems to coincide closely with that of the Red Marl in the bottom quarry, Stony Stanton, where on the north side it rises from the cutting near the Sapcote Road. The manner in which the marls exhibit a radial dip around the syenite bosses was noticed in 1884 by Mr. Harrison. There is here, as elsewhere in the case of these syenite knolls, no intervening Lower Keuper Sandstone, which has its eastern limit defined by a line drawn from near Desford to a point between Hinckley and Elmesthorpe in the south.

The Upper Keuper Sandstone of Croft is not traceable directly between that place and Narborough, but at Newhall Park a thin band strikes north nearly as far as the King's Stand, and forming a wide outcrop between there and Narborough Wood House, swings round in a crescentic manner to the east, dying out north of the latter place. The Red Marl where it is in contact with the igneous rocks is not underlaid by Lower Keuper.

At Enderby, at Marston's Old Quarry in Coal Pit Lane, 10 feet of drift overlies red and green marl, with a thick skerry or sandstone, the equivalent of the Upper Keuper Sandstone, 12–15 feet, lying over tilted syenite, with dome structure. The lowest beds exhibit a clearly defined sharp junction with the marls, which lie on them horizontally, only in one place, over a dome, as at Longcliffe, assuming a slightly undulatory character. Many small thin layers are massed together, and where separated by projections, like the dome, continue uniformly on either side. Harrison describes these sandstones as 2–4 feet thick, and says that they "follow the irregular surface of the granite, and in one place fill up a deep hollow in the rock so as to be perceptibly curved". He also says that "there are thin courses of sandstone and intervening way boards of green marl in the Red Marl and a thin bed of limy breccia at the base".

Due east of Enderby, at Hafford's Brickyard, near Blaby, a section in Red Marl underlying 6–22 feet of drift, a great part of which is reconstructed Red Marl, shows green marl and skerry, replaced by marl with red and green spots 1 foot thick, and 5–6 feet of Red Marl with 2–3 feet of reticulated gypsum, similar to that at Thurmaston. These beds are similar to those seen in Barrow's Pit (west of the Midland Railway) at Thurmaston, dry, light-red, very sandy, having a burnt appearance, and very flaky and ferruginous. A cutting in the Great Central Railway adjacent to this shows Red Marl 6–10 feet and more compact gypsum 2–3 feet. Elsewhere the Great Central Railway line between Leicester and Lutterworth shows no sections in the marls.

At Braunstone J. Plant stated in 1856 the Upper Keuper Sandstone was exposed in the Braunstone Turnpike Road with a dip of 3 degrees to the east. It has recently been exposed in that direction in shallow excavations at Westcotes and towards Braunstone near the footpath to the village across the fields from Narborough Road, but it is not exposed at present near the main turnpike road. J. Plant in 1858 also said "the strata which form the ridge of land on the west side of the valley running by Enderby, Braunstone, Rowley Fields, and Dane Hills were once connected with similar strata upon the opposite ridge on the east of the same valley". The observations of Browne (1893) and later observers have shown this view to be erroneous. They are absent in the Crown Hill boring. South of the West Bridge line, the Upper Keuper Sandstone is traceable between Braunstone and the Hinckley Road at a number of points and crops out to the south of the latter at several places, being well exposed in the cutting, and sweeps round with a sinuous outcrop in the direction of Narborough Road. Numerous sections to the east show that it extends in the direction of Aylestone, but, as demonstrated by Browne in his exhaustive memoir upon the geology of the Borough of Leicester, it thins out and is ultimately lost.

Selecting one of these where an interesting fauna was observed between Norman Road and Aylestone Mill, on the Aylestone Road, we cannot do better than quote Browne's remarks: "The hill between these two points is upheld by two or more thick beds of hard and compact Upper Keuper Sandstone with intercalations of hard grey marls (skerries), the lowest member being Upper Keuper Red and Grey Marls. South of Norman Road the sandstone has thinned out at 5 feet below the surface, and is, between that road and the preceding section [Granby Road], replaced by pieces of more impure sandstone." The section is 9–25 feet in thickness, and the beds dip to the river at 3 degrees.

The fossils found in the gritty sandstone between the marls were—

Estheria minuta.
Acrodus keuperinus (teeth).
Colobodus frequens (scales) } then new to
Gyrolepis quenstedti (scales) } Britain.
Fish-scales.
Amphibia (bones).

The Red Marl comes on just to the east of this section, at Saffron Lane, where 24 ft. 6 in. to 42 ft. 6 in. of Red Marls, Green Marl, and skerries are exposed, underlying Drift deposits. A few thin bands of fibrous gypsum are present in a thick bed 10–12 feet of nodular Red Marl. Below this comes sandy marl like that at the south end of the Thurmaston pit, which suggests that the skerry in the Thurmaston Pottery is Upper Keuper Sandstone. Below this again the lowest bed is flaky and ferruginous like the bottom bed of Barrow's Pit, Thurmaston (west of the Midland Railway), supporting this correlation.

In an adjacent pit at Knighton Junction brickyard, 36 ft. 6 in. to 51 feet of Red Marls and Green Marl and skerries, with ball gypsum, is exposed in a fine section of the upper beds. Three beds of gypsum are exposed, two over 1 foot thick. The lowest is encrusted with selenite crystals as at Vass's Pit, which is on the same horizon. In places the line of gypsum is replaced by Green Marl, with which it is often associated generally.

Where thick-bedded the Red Marl is similar to that at Gipsy Lane, District (4). The gypsum is often perforated by holes, as at Belgrave. The under surface has an exterior like that produced by raindrops due to some chemical agency. The gypsum is white as a rule, but tinged red in contact with the Red Marl, and is very hard and like alabaster. There is little fibrous gypsum here.

(*To be continued in our next Number.*)

REVIEWS.

I.—Geological Survey of Ireland.

The Interbasaltic Rocks (Iron-ores and Bauxites) of North-East Ireland.

By G. A. J. Cole, S. B. Wilkinson, Alexr. M'Henry, J. R. Kilroe, H. J. Seymour, C. E. Moss, and W. D. Haigh. Dublin: printed for H.M. Stationery Office by Browne & Nolan, Ltd., 1912. 8vo; pp. vi, 129, with 6 plates, 23 text-illustrations, and 2 coloured maps. Price 3*s*.

FREQUENT mention has been made in memoirs of the Survey to the interbasaltic beds of the North of Ireland, but the recent development of the mineral industry in that area has made a re-survey desirable. The mode of origin of the materials of this conspicuous zone has been a subject of some discussion, and the first chapter in the present memoir is concerned with the progress of observations in this direction. The origin of similar materials in other regions is discussed, and the conclusion arrived at here is that the bright-coloured deposits originated in Eocene or Oligocene times under hot but not arid conditions, similar to those prevailing at present in tropical India or Africa.

In this memoir the area under consideration is divided into four districts—the Northern, East and Mid-Antrim, and the Southern districts. So far as the Northern district is concerned the types of deposits are different in character and mode of occurrence, and do not all seem to be found together. By far the most important section is that at the Giant's Causeway, where the zone indicates an interbasaltic epoch of long duration, this conclusion being supported by the presence of frequent thick beds of lignite. At numerous localities thin bands of the bright-red bole occur at other horizons, i.e. unconnected with the main interbasaltic zone. It is suggested that these red bands mark periods of rest between the flows, giving time for the decomposition of the successive surfaces of the basalt. In East Antrim the series is represented by two types—red and brown pisolitic iron-ore and lithomarge, or grey bauxitic clays. As noticed in the previous memoir, one type usually occurs to the exclusion of the other. The two sections on Island Magee show that lithomarge is due entirely to the decomposition of the basalt *in situ*, and is not composed of volcanic ash as was formerly thought. Some alterations in the boundary-line between the upper and lower basalt have been necessary in this area, but in the Mid-Antrim district they are not of great importance so far as the area of the mineral deposits is concerned. In the latter district the best iron-ore and bauxite prospects have already been taken up by companies, and details of the various mines are given. Great changes of level occur in the zone, and some may be accounted for by the irregular surface of the lower basalt on which the deposit was formed. There seems to have been a fairly regular drop to the south of about 100 feet to the mile, but of course the original floor of the lignite, iron-ore, and bauxite deposits was probably more or less horizontal.

There is but little to add to existing knowledge of the rocks of Ballypalady and Tardree in the Southern district, but the recent sinking of pits in the Lough Neagh clays has rendered a few new facts available. At Claremont, north-east of Cranford Bay, there is a section of considerable interest, because it suggests that some of the lignite beds in the clays are derived from the interbasaltic zone by denudation. A new explanation for the origin of the remarkable Coagh Conglomerate is brought forward, namely, that it is a much weathered basalt in which the spheroidal structure is highly developed.

Following the description of the outcrop of this zone is a chapter on the plant-remains by Dr. C. E. Moss, who gives a cautious view of the evidence they afford. The Antrim leaf-beds seem to give fairly reliable evidence of climatic conditions, but as regards further evidence Dr. Moss quotes Starkie Gardner's conclusion as still applicable, that "where nothing definite is known, it would be no service to science to add further to the guesses".

Analyses of the ores have been collected from various sources, and are arranged in order as the localities are dealt with in the text. There are two appendices, one by Mr. J. D. Kilroe and the other by Professor G. A. J. Cole. The former discusses the westerly extension of the Upper Basalts, and arrives at the conclusion that the great series to the west of Bann may be to a large extent Upper Basalt. Professor Cole in dealing with the problem of the Lough Neagh clays regards the evidence now available as indicating the post-basaltic age of these clays. If this view be accepted—and the absence of dykes penetrating them is a strong argument in its favour—then the contained nodules (in which a doubtful *Viviparus* as well as the wood and leaves has been found) must be derived from the disintegration of some interbasaltic zone.

II.—Geological Survey of Great Britain.

Geology of the Country around Winchester and Stockbridge. By H. J. Osborne White, F.G.S. pp. iv, 89, with 12 text-illustrations. 1912. Price 1*s*. 6*d*.

THIS latest, ably written memoir by Mr. Osborne White is concerned with an area of which the greater part is in western Hampshire and the rest in south-east Wiltshire, Stockbridge occupying a central position, while Winchester is in the south-east. The oldest formation exposed is the Lower Chalk, which is seen around Chilcomb in the south-eastern corner. The rest of the succession of the Chalk, to the zone of *Belemnitella mucronata*, occupies the greater part of the area, and Eocene beds extend over part of the southern portion.

Following a general account of each division of the Chalk, full details of the exposures are given, and a long and useful list of fossils is added. It is doubtful whether the zone of '*Schloenbachia*' *varians* comes to the surface, but its existence is proved by two borings; and the outcrop of the Middle Chalk seems to be confined to a small area round Chilcomb. As is well known, the Chalk Rock (called by Mr. White the subzone of *Heteroceras reussianum*) of this area does not present the peculiar lithology that characterizes it in other districts, but its fauna, which comes in a few feet above the base of the *Holaster planus* zone, has been found round Winchester and at Stockbridge. Only the lowest beds of the *Belemnitella mucronata* zone are present, and probably the thickness of these does not exceed 50 feet in the aggregate.

Clays, sands, and pebble-beds make up the Reading Beds as developed south-west of Winchester, and of these the Bottom-bed is the only constant member. The junction of these beds with the Chalk is well seen in the railway section near Kimbridge, described by Sir J. Prestwich. The London Clay is in this area about one-third its thickness at Southampton, but, as the author shows, the northward thinning is only apparent; and the Basement-bed is not so prominent as in the London district. No good exposure of the junction of the London Clay with the Bagshot Sands has been observed. Near the River Test these Lower Bagshot Beds consist chiefly of yellow and buff fine-grained sands with layers of impure pipe-clay and of flint pebbles. Of the Bracklesham Series only the lowest beds are exposed in this area, and these consist of light-coloured sands and glauconitic loams in which drift-wood and remains of marine shells are sometimes found.

Having considered the Cretaceous and Tertiary rocks, the author gives an instructive chapter on the tectonic structure and land forms, and describes the three well-marked anticlines of Stockbridge, Winchester, and Dean Hill. He then considers the superficial deposits —the clay-with-flints, the gravels, and the alluvium. From the last-named deposit numerous shells have been collected, and a list of fifty-two species, revised by Mr. A. S. Kennard, is given. The last chapter is devoted to economic geology, and deals with soils, road-metals, and building materials; and the hydrology of the district is briefly discussed.

III.—Guide to the Collection of Gemstones in the Museum of Practical Geology. By W. F. P. McLintock, B.Sc. pp. iv + 92, with 43 figures in the text. Printed for His Majesty's Stationery Office. 1912. Price 9*d*. net.

THIS Guide seems to have been overlong in passing through the press. The preface, which was written by the Director of the Geological Survey, is dated March 29, but more than eight months elapsed before the book actually appeared. No doubt the delay was partly caused by Mr. McLintock's transference to Edinburgh. His Majesty's Stationery Office, under whose auspices the book has been printed, cannot be congratulated upon the quality of the paper or the general get-up of the book.

The Guide is intended to serve the twofold purpose of enabling the visitor to find the various gemstones among the non-metallic minerals, with which they are incorporated in the Museum collection, and to identify cut specimens by certain physical characters. It is divided into four chapters, which, on the whole, follow the usual lines: (1) the properties of gemstones, (2) the cutting of gemstones, (3) the imitation, treatment, and artificial formation of gemstones represented in the collection, (4) the description of gemstones. The author of a guide of this kind is faced with the problem how to avoid technicality which would repel the ordinary visitor, and yet to include enough information to make it of real use. On the whole, Mr. McLintock has steered a deft course, and has provided much interesting and readable matter, which is purchasable for a very modest sum.

The specific gravity is the character upon which most reliance is placed for distinguishing one species from another, and various methods for determining it are described. This test unfortunately necessitates the stone being unmounted, and is not very convenient for the retail jeweller or the purchaser of jewellery. The use of an ordinary balance for the purpose might, with advantage, have been described, since few jewellers possess the Westphal balance. The more generally useful test depending on a measurement of the refractive indices and the double refraction is only just alluded to, and the amount of information given is too small to explain the method. In the instrument mentioned on p. 16 the indices are read off directly on a scale, and no calculations are needed as the reader might be led to suppose. The dichroscope and its applicability are more fully dealt with, and in an interesting paragraph the effect of radium emanations upon the coloration of gemstones is discussed. The Museum collection contains some fine specimens, including the gold snuffbox, set with sixteen brilliant-cut diamonds and the large vase of avanturine quartz which were presented to Sir Roderick I. Murchison by the Czar Nicholas I, and the large vase of "Blue John", which is one of the finest examples of this kind of work existing.

In turning over the pages a few points call for notice. The carat weight is used for all gemstones which have any claim to be accounted precious, but for some reason the discussion of it is placed under 'Diamond'. It is not made clear that the Board of Trade takes no responsibility for the carat and possesses no standard of it; it is, indeed, an illegal weight. All the Board has done is to determine the equivalent in milligrams of the carat in use among English jewellers. In the chapter on the cutting of gemstones too much importance is given to the rose-type, which is never found in modern jewellery, and the facets in figs. 11 and 14 are much too steep. It is puzzling to find the pyroxene group (p. 81) placed in the section headed 'Iolite', and we look in vain for enstatite, cut stones of which, from South Africa, are sold as 'green garnet'. Andalusite is probably oftener confused with tourmaline than with alexandrite (p. 67). A good supply of rough peridot is usually on the market, and it can scarcely be said "the peridot now put upon the market is generally believed to be derived from old ornaments and jewellery" (p. 71); the remark is, however, applicable to emeralds. We are sorry to see the faulty spelling 'essonite', without the aspirate, perpetuated. Most kunzite is too lilac in tint to be mistaken for pink topaz (p. 83). 'Adze' is not a word peculiar to the Maoris and need not be italicized (p. 85). The Chairman of the Premier Diamond Mine (Transvaal) Company, after whom the great diamond was named, is Sir T. N. Cullinan (p. 42). 'Burma' and 'Burmah' appear within three lines of one another on p. 75. Some mistake has obviously been made in the drawing of fig. 36. The locality for emerald in New South Wales is Emmaville (p. 63). Few, if any, pyropes have a refractive index as high as 1·8 (p. 74).

Some useful tables and a good index are included at the end of the book.

IV.—The Keuper Marls around Charnwood. By T. O. Bosworth, B.A., B.Sc., F.G.S. Being the results of researches in Leicestershire, 1904–11. pp. 1–129, with 47 illustrations. Leicester: published by the Leicester Literary and Philosophical Society. n.d.

CONSIDERABLE additions have been made during the last decade to the literature of the Trias, a subject to which great attention has been paid by the Leicester Literary and Philosophical Society. In the present work, a beautifully illustrated volume, are embodied the results of Mr. Bosworth's researches in the Keuper Marls of a district that affords exceptional advantages for study. These results have already been published in various scientific journals, but the collection and arrangement of them in the present volume will be of considerable use to future workers.

After giving a short account of the literature of the subject, the author proceeds to a general sketch of the geology of the district, making reference to the different easily distinguishable kinds of rock that are contained in the Charnian mass. In describing the features of the old rock-surface beneath the Keuper Marls the author takes as a typical illustration the quarry in Groby village, and most of the descriptions of the quarries are accompanied by detailed maps.

He then deals with the condition of the buried rocks, owing to the preserving influence of the marl covering, and an interesting chapter is devoted to the breccias, stone bands, and rock fragments contained in the marls. On account of the uncertainty that existed as to the mineral composition of the Keuper Marls, Mr. Bosworth made various experiments, the result of which are given in some detail; and in the discussion of the mineral grains, an interesting comparison is made between the larger grains of the heavy minerals, now rounded and smoothed, and those of a Scottish Carboniferous Sandstone, which are in strong contrast.

The author has for some years been collecting data as to the ripple-marks, and he includes a table of observations in this direction. These ripples were formed under shallow water, and were controlled by the prevalent south-west wind.

The last chapter summarizes the facts very clearly, and some conclusions are drawn as to the mode of deposition of the sediments. Mr. Bosworth offers as his interpretation that the sediments accumulated in an inland basin that was partly dry and partly occupied by comparatively deep standing pools, the climate being arid, and evaporation in excess of precipitation. Streams of fresh water flowed into the desert from the hills south-west, on which was precipitated the moisture of the prevalent wind. At times most of the desert would be dry, and the inflowing water would be spread over the plains and be evaporated before reaching the pools. Under these conditions the grey beds would be deposited, while the red marls accumulated in the standing pools.

There are four short appendices to this volume, and these give details of the sections at Gipsy Lane, Hathen, Sileby, and Whitwick.

V.—Brief Notices.

1. Ore-deposit, Dolores Mine, Mexico.—In *Economic Geology* for August, 1912, Messrs. J. E. Spurr, G. H. Garrey, and Clarence N. Fenner give an interesting study of the metamorphic ore-deposit at the Dolores Mine, situated at the east base of a small mountain range near Matehuala, S.L.P., Mexico. The range, which is of blue Mesozoic limestone, overlain by the shales forming the valleys on both sides, is remarkable for an enormous fault of a vertical displacement of 1,500 metres. There are two areas of intrusive quartz-monzonite, showing evidence of dawning magmatic differentiation in situ, and near them are lime-silicate rocks, the product of metamorphism. The ore-deposition is in the order—copper pyrites and pyrites, mispickel, pyrrhotite and pyrites, blende, galena, the third stage being rich in silver. Mr. Spurr elaborates his theory of ore-deposition, one of the most important features of which is that the metalliferous solutions from which ores are deposited originate in and spring from the zone of igneous rock differentiation, which is in the lower part of the zone of crystallization.

2. In the *American Journal for Science* for October, 1912, Mr. E. T. Allen and Mr. J. L. Crenshaw discuss the various kinds of sulphides of zinc, cadmium, and mercury, and the conditions under which they

are severally formed, and throw considerable light on their production in nature. Alkaline solutions always give rise to blende, never to wurtzite, and the former mineral is also formed under suitable conditions from acid solutions. Only one sulphide of cadmium exists, the differences in colour that have been noticed being due to the relative amounts of light transmitted and reflected. Three forms of sulphide of mercury are known, of which one, cinnabar, is stable, and two (one being the rare mineral metacinnabar) are unstable. The authors conclude by saying, "Enough work has already been done to show that the difference in chemical character between acid and alkaline solutions, therefore, in general between deep-seated and surface solutions, is of vital importance in geochemistry." The microscopic study was made by Dr. H. E. Merwin.

3. Palæolithic Man in Jersey.—In the thirty-seventh Annual Bulletin of the Société Jersiase (1912) there is an account by Mr. J. Sinel of the prehistoric cave-dwelling (Cotte à la Chèvre) east of Grosnez Point, St. Ouen, on the north-western coast of Jersey. Here, according to the author, "we have what may be termed a pure early Mousterian station, free from admixture of other types of relics, and a floor undisturbed by floods or any other agencies." Apart from the Palæolithic implements, there was obtained the jaw of a large species of deer in a decayed condition.

Messrs. E. T. Nicolle and J. Sinel contribute a "Report of the resumed Exploration of 'La Cotte', St. Brelade". Here, again, flint implements, all of Mousterian type, have been found in a cave-dwelling; also remains of *Rhinoceros antiquitatus*, reindeer, ox, and horse, which have been identified by Dr. C. W. Andrews; and, of still greater interest, some teeth of Palæolithic man, described and figured by Dr. A. Keith and Mr. F. H. S. Knowles under the name of *Homo Breladensis*.[1]

REPORTS AND PROCEEDINGS.

Geological Society of London.

January 8, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Geological History of the Malay Peninsula." By John Brooke Scrivenor, M.A., F.G.S., Geologist to the Government of the Federated Malay States.

This paper is an attempt to present briefly and in a connected form all the information bearing on the geological history of the Malay Peninsula that has been gathered during the course of economic work since 1903.

The main points are as follows:—

During the Mesozoic Era earth-movements took place in a part of the crust which is now the site of the Malay Peninsula. These

[1] A brief notice of the discoveries was communicated to the Geological Society by Dr. A. S. Woodward, Quart. Journ. Geol. Soc., vol. lxvii, p. iii, 1911.

movements resulted in the formation of two large anticlinal folds. The folding admitted of the intrusion of two masses of granite, and the intrusion was accompanied by faulting of the rocks in the folds, and by 'magmatic stoping' on a large scale.

The rocks affected by the folding are the Raub Series of calcareous rocks, and the Malayan Gondwana rocks, resting unconformably on the Raub Series, and in many places faulted down against that series.

The palæontological evidence afforded by small collections from the Raub Series cannot be reconciled with the field evidence. No fixed horizon has been discovered in these rocks, which may be either Carboniferous or Permo-Carboniferous. Associated with the Raub Series are volcanic rocks, which are evidence of contemporaneous submarine eruptions. The eruptions continued into later times.

At the base of the Gondwana rocks are glacial deposits that may be referred to the same horizon as the late Palæozoic glacial deposits of Peninsular India, the Salt Range, Australia, and South Africa, but this horizon cannot be defined exactly in the terms of the European sequence. Its presence shows that the Raub Series must be older than the *Productus* beds of the Salt Range, or equivalent to the shales below the boulder-bed in the trans-Indus section of the Salt Range.

The glacial deposits are succeeded by littoral deposits, and far to the east of the glacial deposits a Rhætic horizon has been described in them by Mr. R. B. Newton, and named by him the Myophorian Sandstone. To account for the apparent discrepancy in age between the climatic horizon afforded by the glacial deposits and the Myophorian Sandstone, an hypothesis has been adopted to the effect that the Malayan Gondwana rocks were deposited on the Gondwana-land coastline as it moved slowly eastwards, probably with many checks and oscillations.

The glacial deposits show that this portion of the Gondwanaland coast contained stanniferous granite and also much corundum. This granite is called 'the Palæozoic Granite', as distinguished from 'the Mesozoic Granite'; it is not known in situ. The glacial deposits are therefore part of a Palæozoic tin-field, now being worked at the same time as the stanniferous deposits derived from the Mesozoic Granite.

Denudation has brought to light the two great anticlinal folds and the granite masses upon which they now rest. On the west is the Main Range Anticline, on the east the Benom Anticline. The eastern limb of the former and the western limb of the latter meet in the Main Range Foothills. The eastern limb of the Benom Anticline is formed by the main Gondwana outcrop, which includes the highest peak in the Peninsula (Gunong Tahan, altitude 7,188 feet). It is believed that this main Gondwana outcrop is continued through the Peninsula to Singapore, and on to Banka and Billiton, where it may turn so as to enter Western Borneo, forming an inner arc roughly parallel with the outer volcanic arc of the Malay Archipelago and the Philippines.

The igneous rocks of the Benom Anticline are less acid than those of the Main Range Anticline, and there is a corresponding difference in mineral products. The area of the Benom Anticline coincides with the 'gold-belt' of the Peninsula. The products of the Main Range Anticline are tin and wolfram.

Tertiary Coal-measures, unconformable on the Gondwana rocks, are known in Selangor. Their exact age cannot be determined, since the flora resembles the existing jungle flora; and the same may be said of floras in Borneo Coal-measures that are believed to date back to the Eocene Period. An arrangement based on the percentage of moisture in the coal, however, points to the possibility of their being Miocene.

Evidence has been found in the Peninsula supplementing the biological evidence described by Dr. A. R. Wallace of changes in the Archipelago in Tertiary times. When the land-connexion that allowed the migration of the fauna of the Archipelago from the north was destroyed by submergence, the subsidence continued until the Peninsula became an island or group of islands. Subsidence then gave place to elevation, which restored the Peninsula and is continuing at the present day.

Interesting recent deposits are deposits of lignite in 'cups' formed by solution in the limestone of the Raub Series, and torrential deposits made up of 'core-boulders' derived from weathered granite.

2. "On a Mass of Anhydrite in the Magnesian Limestone at Hartlepool." By Charles Taylor Trechmann, B.Sc. (Communicated by Professor E. J. Garwood, M.A., V.P.G.S.)

The harbour of Hartlepool owes its existence to the erosion of a mass of anhydrite of great thickness, proved by boring and other evidence to exist in close proximity to the Upper Magnesian Limestone upon which the towns of Hartlepool and West Hartlepool are built.

The anhydrite is shown to be included in, and to represent the time-equivalent of part of, the Middle and the greater part of the Upper Limestones. The contrary view, that the anhydrite belongs to the overlying red beds here faulted down, is shown to be erroneous.

The former presence of sulphates in the Magnesian Limestone is discussed. This formation, wherever protected by overlying comparatively impervious beds, proves to be more or less gypsiferous throughout its thickness. Evidence is brought to show that very large quantities of anhydrite were originally deposited with the Magnesian Limestone, the subsequent hydration and removal of which is chiefly responsible for the collapse, degradation, brecciation, and other alterations that are such obvious features of the formation in its present condition.

The distribution of organisms in the Magnesian Limestone was largely influenced by the quantity of sulphates present in the surrounding water. The Shell Limestone is shown to be a chain of reef-knolls, in the building up of which a limited number of forms take part, probably induced by current action in the Permian sea and lying more or less parallel with the old Permian shore-line. The increasingly unfavourable conditions prevailing towards the top of the Shell Limestone bring about a dwarfing and gradual extinction of the typical Shell Limestone fauna.

The curious distribution and present position of the Upper Magnesian Limestones in Durham is noticed, and an explanation offered.

The Permian succession is shown to be more complete in the southern than in the northern area of the county.

Various sections in the Upper and Upper Middle Limestones in the Hartlepool area are described, among them the recent sinking for Blackhall Colliery, where all the series were pierced, including the full thickness of the Shell Limestone.

CORRESPONDENCE.

SEA-WATER AND CRITICAL TEMPERATURES.

SIR,—I have been very much interested in Professor Bonney's contribution to "The People's Books" in his *Structure of the Earth*. From repeated inquiries for such a clear and lucid introduction to geology, I know by experience how much such a work has been wanted.

It is, of course, a great pleasure to myself to note the stress that Professor Bonney lays on Professor Arrhenius' view of the penetration of the rocks by sea-water, both under pressure and by means of capillary attraction; but, in justice to the fathers of geological science, I should like to point out that Sir Henry de la Beche taught the doctrine of the entrance of sea-water into the earth's crust by pressure; that Professor Daubrée proved by experiment the power of capillary attraction to overcome the opposing resistance of steam as published in 1879 in his *Géologie Expérimentale*, ch. iii; and that Professor Judd, in 1881, endorsed and popularized this doctrine in his *Volcanoes, what they are and what they teach*, pp. 358, 359, besides pointing out the importance of the critical temperatures of liquids in the same work, p. 63.

Daubrée supposed that granite would ordinarily be very impermeable to water, and suggested the possible access of water through dykes of porous rocks ("par des injections de roches éruptives," loc. cit., p. 242). I, however, in 1890 showed that "under extreme changes of temperature granite cracks throughout", and that "a minutely cracked granite would suck in salt water like a sponge, either under pressure or by *capillary* attraction".[1] The experiment is simple, viz., to heat a piece of granite in an ordinary fire, and to soak it when cool in coloured water. I respectfully submit that the important question of the penetration of rocks by water was, long before 1880, promoted from the rank of a mere 'view', even of so distinguished a chemist as is Professor Arrhenius.

I have often wondered why the convincing experimental demonstrations of Professor Daubrée were so completely ignored in the closing decades of the last century, and venture to suggest the following as a possible explanation. In mid-Victorian times all educated people were expected to know something of the French language, but they rarely knew German. About 1870 German

[1] Rep. Brit. Assoc. 1890, p. 815.

became the language desirable for scientists, and French was allowed to lapse. Being a pre-Darwinian myself I can read Daubrée with pleasure, but German is to me a sealed book scientifically.

The French writers on physical geology, such as Daubrée, Delesse, Fouqué, and Lévy, appeal greatly to the followers of the old-fashioned English methods of experiment and demonstration, with the avoidance of 'views', and when possible of 'theories'.

As readers of the Geological Magazine are, perhaps, too well aware, I pressed the two subjects of the permeation of rocks by fluids and of the critical temperature of liquids on them at every possible opportunity between the years 1892 and 1903, having in the year 1892 entirely renounced further original work, as being quite futile so long as the main principles were denied, and retiring entirely in 1904 when tacit opposition became too pronounced. I remain more and more convinced that since the waters first covered the earth no single agent has been more active in the processes of rock-metamorphism than the oceanic waters, charged as they are with soda, potash, magnesia, and lime.

A. R. Hunt.

Torquay.
December 31, 1912.

OBITUARY.

ELLEN SOPHIA WOODWARD.

Born August 7, 1836. Died January 10, 1913.

The beloved wife of the Editor of this journal, and the compiler of a *Forty Years Index to the Geological Magazine, 1864–1903* (Dulau & Co.), passed peacefully away, after fifty-five years of happy married life, on January 10, 1913, at 13 Arundel Gardens, Notting Hill, W.

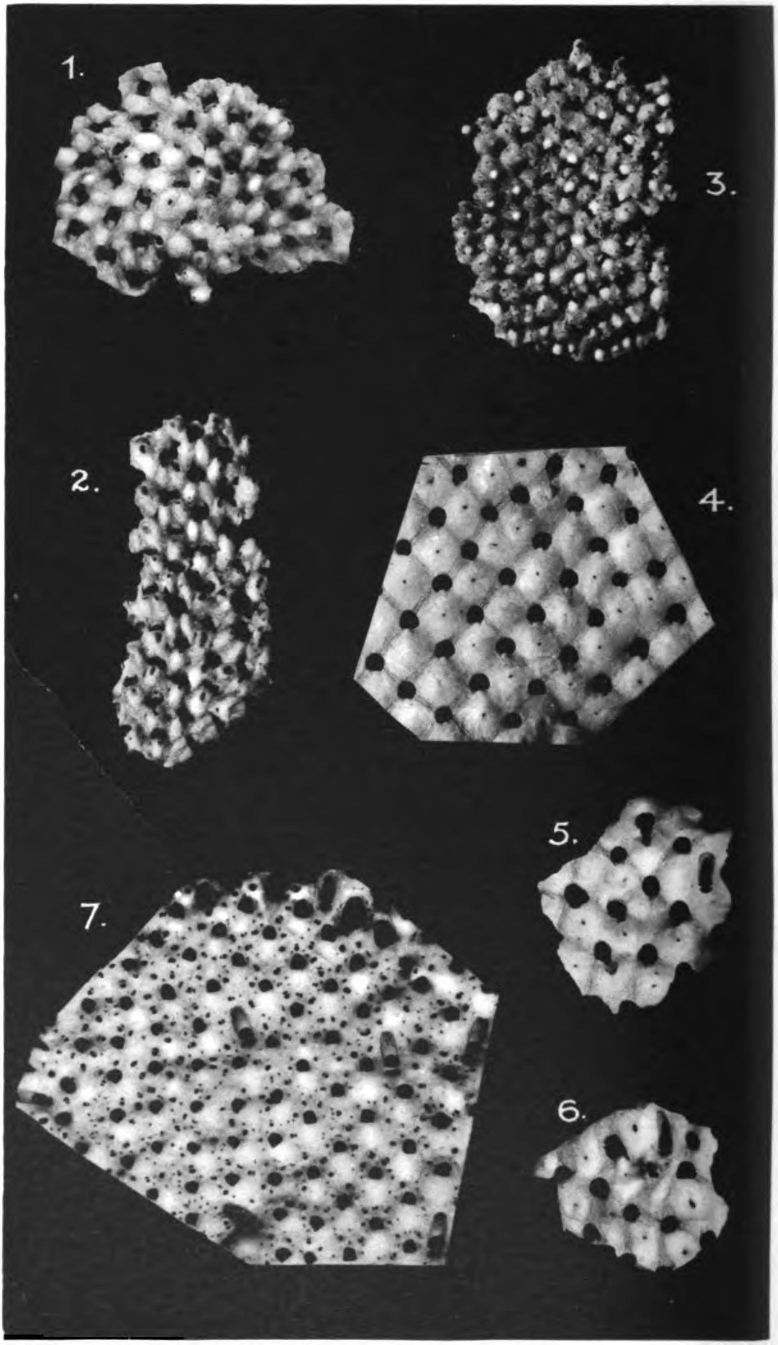
She took a keen and active interest in science, and greatly assisted Dr. Woodward in his geological and literary work, both in the British Museum and at home. She also accompanied him, for many years, to the meetings of the British Association and on visits to the Continent.

MISCELLANEOUS.

Retirement of Mr. Clement Reid, F.R.S., F.L.S., of the Geological Survey of England and Wales.

Mr. Clement Reid, District Geologist on the Geological Survey, retired from the public service on January 6, 1913. He joined the staff of the Survey in 1874, under Sir A. C. Ramsay, and has been actively engaged in field-work for more than thirty-eight years.

Mr. Clement Reid is distinguished for his knowledge of the Tertiary floras, and is the author of many papers and Survey memoirs, including the *Origin of the British Flora*, 1899. He was awarded the "Bigsby Medal" in 1897, and was elected a Fellow of the Royal Society in 1899.



R. M. Brydone, Photo Bemrose, Collo.

Chalk Polyzoa.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. III.—MARCH, 1913.

ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from Vol. IX, p. 435.*)

(PLATE IV.)

Mucronella (?) Spenceri, sp. nov. Pl. IV, Figs. 1 and 2.

This species is very closely related to *Mucronella* (?) *Batheri*.[1] It is, however, generally on a much larger scale; and the single tube or paired tubes lying on or in the convex front wall are very much larger in proportion and occupy nearly the whole of the front wall, with the result that they determine the general level of the zoarium. The aperture is sunk deep below the general zoarial level at the foot of the front-wall tube or tubes, and therefore much overshadowed by them; it is semicircular, and has a small rounded tongue projecting horizontally from its lower lip. More often than not a small oœcium is present, but even that lies wholly below the general zoarial surface and makes very little show. The rule that a zoœcium which begins a new line has one front-wall tube, while a zoœcium which lies in a line already established has a pair, is less strict than in *M.* (?) *Batheri*, but is still a fairly general rule, especially in the later stages of the zoarium.

This species occurs chiefly in the zones of *Offaster pilula* and *Act. quadratus*, but occasionally in lower zones. Even when perfectly preserved it is apt to be very vague and indefinite in aspect, and it is anything but easy to recognize its structure; after specimens have suffered a little damage the deep cups in which the apertures lie take on a very considerable resemblance to the open areas of a *Membranipora*, and then its prominence to the naked eye relatively to its area is often the surest indication of its true nature. The original figure of *M.* (?) *Batheri* was inadequate, and I give a fresh figure of the type for comparison. It seems hardly possible to assign these two species satisfactorily to *Mucronella*, even if they can be brought within the formal definition of that genus; and if, as I strongly suspect, they are allied to *Cryptostoma gastroporum*, Marss.,[2] they might well be transferred to Marsson's genus. This point can hardly be determined from figures only.

[1] Geol. Mag., 1906, pp. 289 et seq.

[2] *Die Bryo. d. Weiss. Schreibkr. d. Inseln Rugen*, p. 96, taf. x, fig. 6.

HOMALOSTEGA CAVERNOSA, sp. nov. Pl. IV, Figs. 4–6.

Zoarium always free and unilaminate, thick and strong.

Zoœcia diamond-shaped and convex, the outlines marked only by hollows, no sutures being observable; apertures in depressions at the points of the diamonds and circular except for a slightly flattened lower end; in the front wall there is a shallow chamber extending from the centre of the front wall, where it communicates with the surface by a pore, to the edge of the aperture over which it opens by a horizontal tubular opening, the upper edge of which when perfectly preserved impinges slightly on the true outline of the aperture. These openings are the only indication of the existence of this chamber in a perfectly preserved specimen, but it is frequently exposed in damaged specimens by the breaking away of its roof.

Oœcia not observed.

Avicularia rare, vicarious, occurring as long narrow cavities with rounded ends; deep down in them there appears at the upper end a narrow horizontal front wall which tapers away towards the middle of the avicularium, but does not wholly disappear from sight until at a point a little below the middle of the avicularium two slender denticles spring from the edge of the avicularium at the general zoarial surface-level; these probably are the remains of a bar spanning the avicularium, of which, however, no instance has yet been observed; below these denticles the side walls of the avicularium are no longer horizontal but sloping steeply inward round the semi-circular lower end.

The species occurs from time to time at Trimingham. There is a distinct suggestion of relationship between it and *Mucronella* (?) *Batheri* and *M.* (?) *Spenceri* in the front-wall chamber of the one and the front-wall tubes of the others, which is, however, much weakened by the presence of vicarious avicularia; and I have placed it under *Homalostega* so as to keep it near *H. suffulta*, Marsson,[1] which seems likely to be even more closely allied to it.

HOMALOSTEGA VULCANI, sp. nov. Pl. IV, Fig. 7.

Zoarium unilaminate, always encrusting.

Zoœcia bounded only by very faint hollows, no sutures being discernible, with slightly convex front walls and shortish heel-shaped apertures, which often have their lower lips slightly turned up; they are very freely sprinkled with small volcano-like eminences, some proportion of which are shown to be avicularian by the preservation of the mandibular cross-bar, which makes it probable that all the others are also avicularian. These eminences show a strong tendency to lie in a rough semicircle round the apertures along the hollows which indicate the zoœcial boundaries.

Oœcia not observed.

Avicularia of two sorts, (1) the accessory kind above mentioned, (2) vicarious; the latter are not infrequent, and have a strong general resemblance to those of *H. cavernosa*, but their sides are not straight but slightly bulging, and the front wall occupies all the

[1] *Die Bryo. d. Weiss. Schreibkr. d. Inseln Rugen*, p. 95, taf. x; fig. 4.

upper half of the area and then dies away very rapidly round a practically circular aperture; the lateral denticles are shown to be the remnants of a cross-bar by the preservation of such a bar in a few instances.

This species, which occurs from time to time at Trimingham, is placed under *Homalostega* on account of its general similarity to the preceding one.

EXPLANATION OF PLATE IV.

(All figures × 12 diams.)

FIG. 1. *Mucronella* (?) *Spenceri*, nov. Zone of *Offaster pilula*, West Meon, Hants.
,, 2. *Mucronella* (?) *Spenceri*, nov. Zone of *Act. quadratus*, East Tytherley, Hants.
,, 3. *Mucronella* (?) *Batheri*, mihi. Type-specimen. Trimingham.
,, 4. *Homalostega cavernosa*, nov. Trimingham.
,, 5. ,, ,, ,,
,, 6. ,, ,, ,,
,, 7. *Homalostega Vulcani*, nov. ,,

II.—THE ORIGIN OF SEPTARIAN STRUCTURE.

By A. MORLEY DAVIES, A.R.C.S., D.Sc., F.G.S.

THE explanation of Septarian structure, almost universally accepted in England, is stated as follows by Sir A. Geikie: "Septarian—a structure often exhibited by concretions of limestone and clay-ironstone which in consolidating have shrunk and cracked internally" (*Text-book of Geology*, 4th ed., p. 136). "In many cases the internal, first-formed parts of a nodule have contracted more than the outer and more compact crust, and have cracked into open polygonal spaces" (ibid., p. 647).

A. H. Green similarly wrote: "Occasionally a contraction of the interior, after an outside solid crust had been formed, produced the cracks of the septaria, in which percolating water deposited a crystalline lining" (*Physical Geology*, p. 280).

J. Geikie expresses himself more cautiously, as indicated by the two words here italicized: "The cracks are widest towards the centre of a concretion, and die out towards its circumference, *as if* the interior had contracted after the outside had dried and become consolidated" (*Structural and Field Geology*, p. 119).

If we go back to De la Beche, we find him also expressing himself with great caution: ". . . the ordinary manner in which such nodules are broken in the interior, the cracks not extending to their exterior surfaces, as if there had been a shrinking of parts from the centre outwards, so that the resulting largest openings were central" (*Geological Observer*, 2nd ed., pp. 597–8).

For years I had, in teaching, adopted this explanation of septarian structure by contraction of the interior, but always with an uncomfortable feeling that I could not maintain it under cross-examination by an intelligent student. Why should the deposition of calcium or iron carbonate between the particles of an argillaceous rock cause contraction in bulk? If it did, why should that contraction be confined to the earliest region affected and delayed until after further deposition had taken place around? These were questions to which I could not suggest an answer, but unfortunately I never had them pressed upon me until on an expedition with Mr. E. E. Lowe, B.Sc., of Leicester, the question was raised between us, and in a few minutes it flashed upon me that the real explanation must be, not contraction, but *expansion*. I have delayed publishing this opinion for over two years in the hope of getting some confirmatory evidence, but the chances of coming across such are so rare that it seems advisable to call general attention to the subject so that many observers may look out for them.

It is obviously more probable that the deposit of calcium carbonate in the interstices of a clay should result in expansion than in contraction. We may think of a concretion as formed by the addition of successive thin shells to a minute original nucleus. This nucleus may be thought of as so minute that it can expand without internal strain. When the first thin concentric shell of clay immediately around the nucleus was impregnated with calcium carbonate, it would expand and tend to separate from the nucleus; but owing to the continuity of deposition it would be too firmly welded to the nucleus to do this. It would therefore exert a tensile strain upon the latter, which would lead to the formation of radial cracks as the sectors of the nucleus were pulled away from their centre. As each successive shell was impregnated and expanded it would exert a similar strain upon the shells within it and the nucleus, so that a series of radiating cracks growing wider inwards would result. It might occasionally happen (owing perhaps to a temporary interruption to the continuous deposit of calcium carbonate) that it was easier for a newly-deposited shell to separate from the next one within than to split it radially; in that case a concentric crack would be formed which would widen later as its enclosing shell was in turn pulled outwards by the expansion of still later-formed shells.

Confirmatory evidence of this explanation is not easy to get. It might be thought that where large septaria occur, not too near together, in a well-laminated shale, the latter might be seen to be more compressed above and below the nodules than between them. But, apart from the difficulties of observation resulting from possible slipping, etc., we must bear in mind that the general compression of the shale is of later date than the formation of the septaria,[1] and it would be hopeless to discriminate between extra compression due to the passive resistance of the already-formed nodule and that due to its expansion during growth.

The only direction in which a crucial test of my explanation seems possible is that of the careful study of the relation of radial and circumferential cracks, especially in regard to width, and I would suggest to all geologists whose work lies among beds in which septaria abound, to keep a look out in this direction.

[1] This was pointed out by De la Beche (loc. cit., p. 597). Fossils which are found in a crushed state in the shale are uncrushed in the concretions. This is the case, for instance, with the Christian Malford ammonites, as Pratt long ago noticed.

It only remains to add that, since planning this paper, I have found that my explanation is not altogether original. It has substantially been given by Seeley, as follows: "As new matter is aggregated to the outside, it is soft, and consists more of clay than of carbonate of lime. Afterwards the carbonate of lime becomes infiltrated into the outer clayey layer, and enters into crystalline combination, so as to expand the outer layer more than the internal part. This splits the concretion internally but not externally, and thus, as the whole mass enlarges, the system of internal cracks also becomes better developed" (Phillips's *Manual of Geology*, pt. i, edited by H. G. Seeley, p. 103).

As this passage does not seem to have attracted attention, and the *Manual* has long been out of print, the present paper seems justifiable.

III.—Note on the Eocene Beds of Hengistbury Head.

By F. R. Cowper Reed, M.A., F.G.S.

The succession of the Eocene beds exposed on Hengistbury Head, near Christchurch, was described in some detail by Mr. J. S. Gardner in 1879.[1] Four divisions were recognized by him, and they were termed in descending order (1) the Highcliff Sands, (2) (3) the Upper and Lower Hengistbury Head Beds, and (4) the Boscombe Sands. No list of fossils from any of these divisions appears to have been published, but on the Survey Map, Sheet 16, the following fossils are mentioned in the beds of Hengistbury Head, though no precise horizon is given:—

Cardium semigranulatum.
Cytherea obliqua.
Solen affinis.
Thracia sp.
Lamna elegans.
Otodus appendiculatus.
Leaves of Dicotyledonous plants.

Prestwich[2] mentioned a *Modiola*, and Mr. Gardner records "a few casts of bivalves" from the lower part of the Hengistbury Head Beds (without giving any generic determinations), as well as sharks' teeth from the ironstones.

During a recent brief visit to the headland a considerable number of fossils were collected by me in the clays between the two upper bands of ironstone concretions exposed in the large quarry on the Head. The upper band of ironstone concretions is here about 5–6 feet below the base of the Highcliff Sands which cap the sides of the quarry, and it was in the lower part of the 6 feet of buff or pale chocolate-coloured sandy clays which lie between this band and the second band of ironstone nodules that the fossils were found. Nearly all of them are in the state of casts and are difficult to extract whole, so that their determination is sometimes difficult or

[1] Gardner, Q.J.G.S., vol. xxxv, p. 209, 1879.
[2] Prestwich, Q.J.G.S., vol. v, p. 43, 1848.

impossible. But about the identification of the following six species there can be little doubt, and they are of importance as marking the horizon :—

Nuculana [*Leda*] *minima.*
Protocardium turgidum.
Corbula pisum.
Crassatella sulcata.
Panopea [*Glycimeris*] *intermedia.*
Calyptræa aperta.

The species about which more or less uncertainty exists or which are indeterminable are the following :—

Anomia lineata (?).
Arca duplicata (?).
Pectunculus [*Axinæa*] *dissimilis* (?).
Cardium cf. *formosum* (?).
Cyrena cf. *crassa* (?).
Meretrix [*Cytherea*] cf. *incurvata.*
Callista [*Cytherea*] (?) sp.
Cardita sulcata (?).
C. (small) sp.
Corbula ficus (?).
C. cuspidata (?).
Tellina sp.
Turritella sp.
Callianassa (?) sp.

Fragmentary plant-remains are common, and the vertebra of a small fish was also found.

The beds immediately below the second band of ironstone concretions have not so far yielded any recognizable fossils, though many fragments of plants form thin seams; but about 8–9 feet below it, that is about 20 feet below the base of the Highcliff Sands, the following two species were collected in a dark chocolate-coloured clay with grains of glauconite, and traces of other mollusca were noticed at the same time :—

Mytilus affinis.
Tornatellæa Nysti.

At the base of the cliffs at the north-east corner of the headland dark-greenish and chocolate-coloured clays are exposed at the beach level and for a few feet above it, and these are in places crowded with grains of glauconite and clear quartz. In these beds about 30 feet below the base of the Highcliff Sands the Echinoid *Schizaster D'Urbani* was found.

The interest of the above-recorded fossils lies in the indication they give of the age of the Upper Hengistbury Head Beds in which they occur. In the Geological Survey Memoir *On the Country around Bournemouth* (Sheet 329), published in 1898, these beds (p. 8) are included in the Bracklesham Series. Prestwich in 1848 (op. cit. *supra*) was inclined to place them in the Barton Series, and the evidence of the fossils which I have collected points to this correlation, for there are no definite or characteristic Bracklesham forms, and all the species identified with certainty belong to the Barton

Beds, and some are typical of them. Mr. Henry Keeping concurs with this conclusion at which I have arrived. Though the material is poor and the fossils not well preserved like those from Barton itself, yet it is probable that further search in dry weather would result in the discovery of other fossiliferous horizons and enable us to fix the line of separation between the Barton and Bracklesham Series in this section.

IV.—*Verruca prisca* from the Chalk of Norwich.

By Thomas H. Withers, F.G.S.

The Cirripede *Verruca prisca* was first described by Bosquet (1854) from the Upper Senonian and Maestrichtian of Holland and Belgium, and he figured detached examples of all the valves.

Darwin (1854–5) knew of only a single example of *Verruca* from the English Chalk, and this came from the neighbourhood of Norwich. It was originally in the collection of J. de C. Sowerby, but, although search has been made in the Sowerby Collection in the Geological Department of the British Museum, it cannot at present be found. This specimen, which was figured by Darwin (1854–5), consisted of the four valves of the shell united, but without the moveable opercular valves, and it was attached to a Mollusc; Darwin thought it probable that it was identical with *Verruca prisca*, but in the absence of the opercular valves could not say so with certainty.

Verruca prisca has been recorded by Marsson (1880) from the Chalk of Rügen, but I can find no further references to the occurrence of this species.

Dr. A. W. Rowe recently submitted to me a Cirripede which I considered to belong to the species *V. prisca*. The specimen, which came from the *Belemnitella mucronata*-zone of Norwich, is attached to an oyster, *Ostrea semiplana*, and, like the example figured by Darwin, has the four valves of the shell united, the opercular valves being absent. More recently Dr. Rowe sent to me, from the same locality and horizon, a portion of a sea-urchin, *Echinocorys scutatus*, to which seven examples of *Verruca prisca* are attached, and two of these fortunately show the opercular valves in position.

The discovery in the English Chalk of no less than eight examples of this hitherto rare Cirripede is of much interest, not only because they are the only known examples from the English Chalk, now that Sowerby's specimen is missing, but because the presence of the opercular valves has enabled me to determine definitely their identity with *V. prisca*, Bosquet. This species, moreover, is geologically the oldest known representative of the family, and, with the exception of *V. pusilla*, Bosquet,[1] of Maestrichtian age, is the only known species from the Cretaceous rocks. It is certainly a remarkable circumstance that we should find two perfectly complete examples of *V. prisca* having all the valves in position, and I believe them to be the only existing specimens of Cretaceous age so preserved.

[1] J. Bosquet, *Notice sur quelques Cirripèdes récemment découverts dans le Terr. Crét. du Duché de Limbourg*, 1857, p. 5, pl. i, fig. 3.

Family VERRUCIDÆ, Darwin.

Sessile, asymmetrical barnacles, in which the shell is composed of six valves, namely, the rostrum, carina, a scutum, and a tergum, all much modified in shape and immoveably interlocked to form the wall, and a single scutum and tergum which are moveable and form the lid-like top.

The family consists only of the single genus *Verruca.*

Genus VERRUCA, Schumacher.

Most of the species of this genus are known by one, or very few examples only, so that very little can be said of the variability in the individuals of a species. This is especially the case with the recent deep-sea forms, which appear to be more nearly related to the Cretaceous species. It appears to be quite a matter of chance whether the right- or the left-hand scutum and tergum are modified to interlock and form the wall with the rostrum and carina, so that individuals of any species may occur with the moveable opercular valves on either the right or the left side.

VERRUCA PRISCA, J. Bosquet.

1854. *Verruca prisca*, J. Bosquet, Les Crust. Foss. du Terr. Crétacé du Duché de Limbourg, p. 14, pl. i, figs. 1–7, 7′.

1854. ,, ,, C. R. Darwin, Ray Soc. Monogr. Sub-class Cirripedia, Balanidæ and Verrucidæ, p. 525, pl. xxi, fig. 4, and Synopsis et Index Systematicus, p. 626.

1855. ,, ,, C. R. Darwin, Pal. Soc. Monogr. Foss. Balanidæ and Verrucidæ, p. 43, pl. ii, figs. 10*a–c*.

1857. ,, ,, J. Bosquet, Notice sur quelques Cirripèdes récemment découverts dans le Terr. Crétacé du Duché de Limbourg, p. 4, pl. i, figs. 2*a–b*.

1877. ,, ,, H. Woodward, Brit. Mus. Cat. Brit. Foss. Crustacea, p. 144.

1880. ,, ,, Th. Marsson, "Cirrip. d. Weiss. Schreibkreide d. Insel Rügen": Mittheil. naturwiss. Vereine von Neu-Vorpommern und Rügen, Jahrg. xii, p. 25.

1912. *Verruca steenstrupi*,[1] K. B. Nielsen, "Cirripedierne i Danmarks Danien-Aflejringer": Meddel. Dansk Geol. Forening, Bd. iv, Hft. i, p. 39, pl. i, figs. 25, 26.

Specific Characters.—Shell elevated, smooth; lower articular ridge of moveable scutum broader than the upper articular ridge.

[1] Seven examples of *Verruca* from the Bryozoa Limestone (Danian) of Faxe, Denmark, have been recently described by Mr. K. Brünnich Nielsen under the new name *V. steenstrupi*. All the specimens are attached to the inside of the cup of the sessile Crinoid *Cyathidium holopus*, and have the four valves of the shell united, but no examples of the moveable opercular valves have been found with them. To judge from the description and figures, there seems little doubt that they are identical with *V. prisca*, Bosquet.

Distribution.—Maestrichtian and Upper Senonian: St. Pierre, Duchy of Limbourg, Holland. Maestrichtian: Sichen, Belgium. Upper Senonian: Frère, near Tongres, Belgium. Upper Senonian, *Belemnitella mucronata*-zone: near Norwich, Norfolk, and I. of Rügen.

The largest example in the present series is attached to an oyster and measures 4·2 mm. in its greatest diameter from the base of the rostrum to that of the carina, while the specimens attached to the shell of *Echinocorys* range from 1·2 mm. to about 4 mm. in the same dimensions; the two examples with the opercular valves in position measure respectively 1·2 mm. and 2·1 mm. Darwin's figure of the Norwich specimen was enlarged to five diameters, and since this figure measures 24 mm. in breadth, the specimen must have been somewhat larger than the largest of the present series. I have already pointed out that it seems to be a matter of chance whether the moveable opercular valves are on the right or the left side, and the four well-preserved examples show this quite clearly.

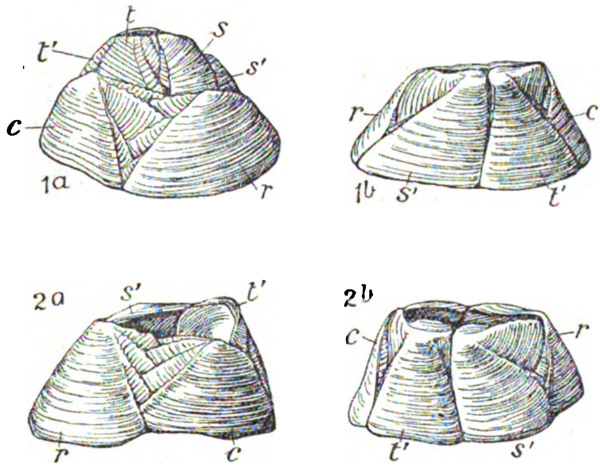


FIG. 1. *Verruca prisca*, J. Bosquet. Upper Senonian: *Belemnitella mucronata*-zone, near Norwich. Complete shell (attached to *Echinocorys scutatus*). (*a*) View showing the moveable opercular valves, which are on the left side; the rostrum and carina have three unequally-developed interlocking ribs. (*b*) Opposite view of same specimen showing fixed scutum and tergum. × 15 diam.

FIG. 2. Id. (*a*) Specimen, attached to *Ostrea semiplana*, with the four valves of the shell united, but in which the moveable opercular valves are missing. The rostrum is to the left hand, therefore the moveable opercular valves must have been on the right side; there are three equally-developed interlocking ribs to the rostrum and carina. (*b*) Opposite view of same showing the fixed scutum and tergum. × 7·5 diam.

r. rostrum; *c*. carina; *s*. moveable scutum; *s'*. fixed scutum; *t*. moveable tergum; *t'*. fixed tergum.

In the specimen attached to the oyster (Fig. 2), and in one attached to the *Echinocorys*, the opercular valves must have been on the right side, while the larger of the two specimens with the opercular valves in position (Fig. 1), as well as the smaller, have these valves on the left side. It is certainly interesting to note that we have individuals attached to the same supporting surface, with the opercular valves on either the right or the left side.

Darwin pointed out in his description of *Verruca prisca* that the plates by which the fixed scutum and tergum are interlocked with those of the rostrum and carina, were 'less-developed' in M. Bosquet's specimen (from Belgium) than in the English. The number of ribs to these valves appears to vary, however, even among the present specimens from Norwich, since the largest specimen has two, while the smaller specimens appear to have only one. In the specimen figured by Darwin from Norwich, the rostrum and carina have only two interlocking ribs. The specimen on the oyster, however (Fig. 2*a*) and one of those on the *Echinocorys* (Fig. 1*a*) have three interlocking ribs on the rostrum and carina, but these ribs are more equally developed in the specimen on the oyster. The valves (? carinæ) figured by Bosquet (1854, pl. i, figs. 7, 7′ *a*, *b*) from Belgium have five interlocking ribs, and in a valve (? rostrum) in the Geological Department of the British Museum, registered I. 15285, which was obtained from J. Bosquet, these ribs are four in number. There appears, therefore, to be some variation in the number of interlocking ribs in the valves of *Verruca prisca*, as well as some variation in the width of the ribs. An examination of a number of recent specimens of *V. strömia* seems to show that the number of interlocking ribs on the rostrum and carina increases with age, since the larger specimens usually have a greater number.

Owing to the smallness of the two specimens mentioned above with the moveable opercular valves in position, it would be dangerous to attempt to isolate the opercular valves to permit of their more thorough examination. I have given enlarged figures of the two largest specimens, however, and these, I think, will be quite sufficient to show their identity with *V. prisca*.

V.—The Age of the Torbay Raised Beaches.

By A. R. Hunt, F.L.S., F.G.S.

Mr. JUKES-BROWNE, F.R.S., in a paper entitled "The Making of Torbay", which has recently appeared in the Trans. Devon Assoc. for 1912, incidentally refers to the Raised Beaches of Torbay as follows: "The age of these beaches has been fairly well settled by the determination of the date of similar beaches in South Wales . . . the beaches testify to a subsidence which culminated either just before or during the epoch of maximum glaciation" (Trans. Devon Assoc. 1912, p. 726).

So long ago as 1849 Mr. Austen (afterwards Godwin-Austen), that prince among sea-going geologists, affirmed that the Raised Beaches of Ireland, Wales, and Devonshire were of the same age. "From the Irish Channel to the western coasts of England, and to those of France and the Channel Islands, we have a continuous series of like phenomena; and if one portion is of Pleistocene age, so is the whole" (Q.J.G.S. 1849, p. 88). Mr. Jukes-Browne has therefore weighty support to rely upon.

Mr. Jukes-Browne unfortunately makes no reference to the voluminous literature of the Raised Beaches which has accreted round Mr. Godwin-Austen's 1849 paper, literature and evidence extraordinary in its variety—geological, conchological, physical, chemical, petrological, anthropological, archæological; indeed, the subject touches all the old sections of the British Association except economics!

In 1890 my friend and colleague the late Mr. Dan Pidgeon, F.G.S., challenged my 1888 paper at the Geological Society. The following geologists took part in the discussion: Sir A. Geikie, Pres.G.S., Professor Hughes, Mr. Clement Reid, and Mr. Ussher. The earliest date claimed by anyone was Mr. Pidgeon's close of the Glacial Age (Q.J.G.S., vol. xlvi, p. 442).

The late Mr. Gwyn Jeffreys had considered that the analogous beach at Portland Bill indicated a temperature equivalent to that between the Shetlands and the Yorkshire coast at the present time.

The intrinsic evidence of the Torbay beaches against an early glacial antiquity is very strong. For one thing, flints of recognized Neolithic age have occurred at Hope's Nose in Torbay, in the Irish beaches, and in the Scotch beaches, all within the 25 foot level or terrace. The shells of these beaches have been pronounced of a decidedly non-Arctic character.

The most northern shell from a Torbay beach, *Trophon truncatus*, necessitates no further a journey than to the Yorkshire coasts. No shells occur in Kent's Cavern till quite late in the Palæolithic deposits; and, of cockles (undoubted food-molluscs), only in the uppermost inches of the newer stalagmite. The puzzling Pecten shells were, in some cases at least, dead shells when introduced.

The Hope's Nose Raised Beach is about ten miles north of the line joining the Prawle Point and Portland Bill; is in a bay within a bay; and appears inevitably to represent a very much later stage of coast erosion. Further, the vast shore-ledge in the hard rocks at the Prawle in South Devon is open to the Atlantic: the southern Torbay beaches were only open to the eastward and to down-channel seas. In fact, geology, geography, conchology, physics, palæontology, archæology, anthropology, and even micro-petrology, all seem to incline towards the conclusion that the Torbay beaches represent the latter days of the vanishing Glacial Age.

P.S.—The statement that '*Trophon truncatus*' necessitates no further a journey than to the Yorkshire coasts was based on the belief that that shell was extinct in the English Channel. This belief, based on Mr. Gwyn Jeffreys' British Conchology, and never, so far as I am aware, challenged, seems now to be unfounded.

On February 17, the day the proofs of the above communication were posted to me, I visited, quite incidentally, the Hertfordshire County Museum at St. Albans to see Roman antiquities. There Mr. G. Ebsworth Bullen informed me, in course of conversation, that in dredging in the English Channel from the Plymouth Marine

Biological Station he had taken *T. truncatus* in mid-channel, and that it also occurred at Guernsey.

So much for a quarter of a century's negative evidence, and the testimony of the fauna of the Torbay Raised Beaches to a rather colder temperature.

VI.—The Picrite of Foel lwyd, Carnarvonshire.

By J. E. Wynfield Rhodes, B.Sc.

During a short holiday to North Wales in Whit-week, 1910, I was investigating the igneous rocks to the south of Llanfairfechan, more particularly the intrusive greenstones of the Geological Survey map. Since the publication of this map, over fifty years ago, several districts within it have been investigated in greater detail, especially as to the volcanic rocks, but much remains to be done petrographically. One of these greenstones turned out to be of exceptional interest, being of a type of rock hitherto, I believe, unrecorded in North Wales, so another visit was made to it in August, 1912.

My attention was drawn to it in the field by its pronounced lustre-mottling, and a fuller investigation revealed in it strong affinities to the augite picrites. It occurs on the southern side of the height Foel lwyd, overlooking the celebrated Bwlch-y-ddeufaen Pass, which connects Aber with the Conway Valley, and outcrops on a dip-slope, which owing to the steep southerly dip is often precipitous. Owing to the interstratification of grits, shales, and igneous rocks, the side of the hill is terraced, each hard band forming a crag. One of these, the lowest, is composed of the rock in question, and it appears to form a sill-like mass, possibly a phacolite, intruded between the grits and shales overlying the so-called Bala Volcanic Series. It appears to send off veins into these rocks. It dies out horizontally, and at the same time the feature ceases to be traceable. The crag is heavily glaciated, although, owing to extensive weathering, striations are not evident.

Petrology of the Intrusion.—In hand-specimens the rock is of a medium grain and of a dark-green colour, becoming lighter on weathering; notable in most specimens for its lustre-mottling. Serpentine bulks to the extent of one-half the rock, diallage is abundant, and felspar is usually to be detected; pyrites occurs locally. Microscopically the rock is seen to contain—

Serpentine, pale green, fibrous, nearly isotropic, interstitially and as granules up to ·03 inch in diameter embedded in augite, apparently pseudomorphing olivine, which must have been the most abundant constituent of the rock.

Augite, in large pinkish brown prisms and grains up to ·16 inch in diameter, with a very pronounced diallage striation, enclosing olivine pseudomorphs (poecilitic structure) and plagioclase laths (ophitic structure); next to serpentine the most abundant constituent.

Bastite, fairly abundant in the serpentine in flakes up to ·01 inch in length.

Ilmenite, in allotriomorphic grains and rhombohedra strongly altered to leucoxene, up to ·22 inch in size (usually smaller), present in small amount only.

Plagioclase, in laths from ·01 to ·02 inch long by ·002 inch wide usually, often much decomposed, well distributed but subordinate in quantity to augite.

Apatite, in very small prisms not exceeding ·003 inch long, and very scarce.

The order of crystallization seems to have been apatite, plagioclase, ilmenite, enstatite (represented by bastite), olivine (represented by serpentine), and lastly augite.

Two varieties of the rock were distinguished: (1) the normal rock, forming the bulk of the intrusion, in which felspar though a constant constituent is not present in large amounts; (2) a more felspathic variety, lighter and greener in colour, occurring at the margins, top and bottom, of the intrusion. It may be suggested that it is the result of differentiation by fractional crystallization, the felspar being the first essential mineral which crystallized in the rock.

In microscopical structure the normal rock is more of a picrite than a dolerite, especially in the dominant role played by olivine in the crystallization of the rock. This interpretation is confirmed by the partial analyses of two specimens which yielded 45·07 and 45·4 per cent of $Si\,O_2$ respectively. On the other hand, there is certainly more felspar in the normal rock than in the most typical picrites, though there is hardly enough for a dolerite, even in the felspathic variety. Augite picrites and olivine dolerites are alike hitherto unrecorded from this district. The nearest outcrops of such basic rocks are the hornblende picrites of the Lleyn Peninsula and of Anglesey.

VII.—The Upper Trias of Leicestershire.

By A. R. Horwood.

(*Continued from p.* 86.)

3. Stratigraphy (*continued*).

The *Dane Hill Sandstone Group*, as we propose to distinguish the higher of the two series of Upper Keuper sandstones, since it is well developed in the neighbourhood of the Dane Hills at Leicester, is well exposed in a little quarry at Ashleigh House. Here the highest part of the series is seen, with thin beds of flaggy marl and calcareous White or Green Marl, overlying a series of thick-bedded, current-bedded sandstones, of white colour, loose and friable, but hardening on exposure. The section has been described by Browne (1893), but at present is exposed to show a better sequence (see next page).

On account of the prevalence of *Estheria* in the marly beds and *Acrodus* in the sandstones they may be distinguished as *Estheria* Marls and *Acrodus* Beds, and the beds below the last as the *Annelid* Bed.

		ft.	in.	
	Humus	1	0	
Estheria Marls.	Brown false-bedded sandstone	0	8	(to 1 foot).
	Fissile green marl	0	2	
	Flaggy brown sandstone	1	0	
	Fissile green marl	1	6	
	Thin flags of sandstone	0	3	
	Fissile green marl	1	0	(to 15 inches).
	Thin layer of marl	0	1	(to 2 inches).
	Sandstone	0	6	
	Fissile marl	0	1	
	Brownish-white sandstone	0	8	
	Fissile marl	0	3	
Acrodus Beds.	Coarse white sandstone	1	0	(to 15 inches).
	Thin marly parting	0	1	
	Coarse sandstone	1	0	(to 18 inches).
	Marly band	0	2	
	Sandstone partly false-bedded	1	6	(to 2 feet).
	Marl band	0	1	
	False-bedded white sandstone	2	6	
	Marl band	0	1	
	False-bedded white sandstone	2	0	(to 2 ft. 6 in.).
		15	7	(to 18 feet).

It will be seen from this that the marly beds are mainly developed above the sandstones. It is in these that abundant traces of *Estheria minuta* occur, but occasionally they are found in the coarse sandstone. Plant-remains and tracks of Crustacea or Annelids occur on the upper marls, but are fragmentary. Some marl bands have carbonaceous bands, especially the lowest. In the sandstones are fin-spines of *Acrodus keuperinus* and teeth of *Acrodus*.

The petrology (*supra*) of these sandstones indicates their fluviatile origin, there being two sizes of grains, none of which show the polished character of desert sands. Kaolinized grains of felspar are abundant, with a varying proportion of heavy minerals. The flaggy beds are ripple-marked and show indications of raindrops and sun-cracks. The sandstones are false-bedded to the south-east, in which direction they thin out, whilst the marl beds, like calcareous strata in normal aqueous deposits, thin out in an opposite direction to the north-west or west. A section showing this was exposed in the Hinckley Road, and was figured by Fox-Strangways.

Recently the hilly ground between this quarry and the New Parks has been opened up for building purposes, and the thick sandstones, here much browner and with numerous black spots, have demonstrated the extension of the beds in this direction. That they were extensive northwards to Newfoundpool is shown by the numerous pits in the hill upon which the new Convent is built. To the east about Dane Hill a lenticular patch is shown by their outcrop and by excavations. A valley separates this tract from the Ashleigh House outcrop and the Shoulder-of-Mutton Hill district. This area is now known as New Parks. In the Western Park, south-west of the Convent, a ballast cutting made when the adjacent railway cutting was excavated shows 8 ft. 8 in. to 15 feet of the sandstones with no overlying marls. These are covered by Drift, and the section is as follows:—

		ft.	in.	
	1. Drift, with quartzites and flints .	12	0	(to 15 feet).
Acrodus Beds.	2. Thin laminated sandy flags . .	0	9	
	3. Thick-bedded sandstone . . .	6	6	
	4. Parting of green marl . . .	0	4	
	5. Thick-bedded reddish-brown sandstone, current-bedded to north-east, with white specks of kaolin and green clay galls	2	0	(to 2 ft. 6 in.).
	6. Green marl	0	4	
	7. Thick-bedded sandstone . . .	0	9	
	8. Thick-bedded brownish-red sandstone	3	0	
		25	8	(to 24 ft. 2 in.).

The top beds contain numerous fin-spines of *Acrodus keuperinus* and teeth of *Acrodus*. *Estheria minuta* occurs in the marl partings. One part of the section to the east shows undulating strata.

In the railway cutting are 6–7 bands of sandstone, and at the west end green marl and gritty sandstone, 6 feet, below the sandstones, which are 20 feet thick. The upper marly beds are absent here. Some marly bands under the bridge are intercalated in the middle of the sandstone beds and exhibit a delta-bedded character dipping to the east. The false bedding at Ashleigh House is similar in parts, having a curved, not straight outline. This cutting is about a mile in length and the beds are finely exposed. Fossils were obtained when the line was opened by J. Plant (see Palæontology), but are difficult to obtain now. Many occur in the flaggy basement beds. Where the Glenfield footpath crosses the line the outcrop forms a branch striking north-west towards Braunstone Frith.

These sandstones are continuous northward along the west bank of the River Soar as far as Mountsorrel, but the outcrop is discontinuous. It is in the Dane Hill or New Parks district that they are best developed in Leicestershire. The similarity of these beds to those in the Warwickshire area, as described by Brodie, is very close, not only lithologically but also from the palæontological point of view. Brodie and others have found the Warwickshire Sandstone more prolific in number of species, and plants especially are better preserved there. This may be due to local conditions, and is not the result of less interest in the formation in this county. The question of the peculiar distribution of the Triassic flora and fauna will be discussed elsewhere.

Turning to the surrounding area in which borings have been made for coal through the overlying Trias, reference may be made to one at Stretton Baskerville (300 O.D.). Here under 130 feet Drift, etc., 242 feet of Keuper Marl, 250 ft. 6 in. Lower Keuper Sandstone reposed upon 58 ft. 6 in. Caldecote volcanic rocks. This thickening of the Lower Keuper to the south is supported by similar sections to the north. The south-easterly attenuation in Leicestershire and district is apparently everywhere modified in proximity to the older rocks.

At Weston, near Bulkington, 300 feet clays, marls, and sandstones, with a bed of limestone half-way down, were attributed by Andrews to the Coal-measures, showing an attenuation of the Trias in this direction. At Combe Abbey to the south, however, 180 feet Red Marl, 75 feet white sandstones or waterstones overlie 25 feet Red Marl, probably Permian or Upper Coal-measures. At Brandon, south-east of this, the section was—

		ft.	in.
Soil		2	6
Gravel		18	6
Keuper Marl		277	0
Waterstones		36	0
Broken ground		6	0
Coal-measures with coal	Black Shale	5	0
	Blue Shale	21	3
		366	3

This shows an attenuation of the waterstones to the east. At Copswood Grange, near Stoke, there were 60 feet Keuper Marl, 82 feet grey waterstones, 97 feet brown and red sandstones, showing a thickening of the middle series again to the west.

(4) *Charnwood Forest District.*

The Charnwood range is circumscribed by the Leicester and Burton line, the Loughborough and Coalville line, and the Loughborough and Leicester line. Since the last runs to the west of the Triassic outcrop on the east, this area is not strictly included within the last boundary, and the outlying tracts are here included up to the Tea-green Marls.

A feature of this area is the unusual manner in which the Trias reposes against the older rocks, seen to some extent in proximity to the southern syenites of Croft, etc., but better displayed with the usual radial dip in this area. There is little or no necessity to enlarge on these features, as Professor Watts and T. O. Bosworth have done so elsewhere, with a different interpretation of these features. It is not the purpose of this paper to enter into discussion as to the causes of these abnormal phenomena in the marls, but simply to record their occurrence. In doing this also features described by the foregoing authors will not here be referred to except where a different account can be given in the light of fresh knowledge. My views as to these phenomena have already been outlined in abstract, unfortunately too briefly to adequately explain my contentions, and a fuller account will be published shortly elsewhere. This will obviate any special allusion to these matters of purely local occurrence in this paper. In the north-west of this area there are exposures of the Lower Keuper Sandstone, and though some writers have stated that it does not encircle the Charnian rocks, yet there are several points in this district where it undoubtedly does.

The Red Marl reaches its highest altitude in Britain here at Bardon Hill, and throughout this district west of the Soar Valley rises generally to a more or less uniform altitude of 500 feet on the west down to 300 feet on the east. Owing to the contact of the Red Marl with the older rocks numerous opportunities of studying it are presented, of which the most interesting sections are here mentioned. In addition the Red Marl is largely used for building purposes, brick- and tile-making in the Soar Valley, and it has been possible for the first time to indicate the correlations of these sections and the position of the beds in the sequence. Some of the most important sections in the Red Marl are to be seen in this vicinity right up to the Tea-green Marl and overlying Rhætic beds. A considerable influence has been brought to bear upon the configuration of the Red Marl by the river-systems, which owe their origin in this area to the Charnwood range, and the River Soar to the east is responsible for the development of the fine series of sections just mentioned.

In the extreme north-west at Gracedieu the basal breccia of the Lower Keuper is seen to overlie the limestone, unconformably, the latter dipping north at 6–10 degrees. There is a limestone breccia at the top in a sandy red matrix, which between here and Griffy Dam is much more brecciated than to the north-west. Between Spring Boroughs and Blackbrook the Lower Keuper Sandstone overlaps the Charnian rocks for a distance of half a mile. It runs up the Blackbrook Valley, and is in turn overlaid by Red Marl which occupies a broad strip in the centre of the valley, dividing the forest into two halves more or less along the anticlinal axis. At Finny Hill Lodge this tract is nearly a mile in width. In these Red Marls there is a bed of white sandstone near the base, which probably represents the white skerry band at Bardon Hill, and those at Copt Oak and Charley. About White Horse Wood or south of it these marls with an interbedded sandstone are seen, and further north a bed of white sandstone has been found to contain galena included in Carboniferous Limestone, and derived from some of the inliers to the north-west. There used to be several old marl-pits in this district in the valley in a lane opposite the wood with a floor of fine light-coloured sandstone, which dipped towards the valley (west) at 8°–10°.

Thirty years ago Shipman discovered galena in the Lower Keuper Sandstone at Shepshed in cuttings for the Charnwood Forest Railway, 1 mile south-west of the village, in a coarse red sandstone under the bridge over the road from Shepshed to Blackbrook. The ore was in pebbles and rolled lumps of impure Carboniferous Limestone, and formed 50–60 per cent of the matrix, which resembled the Dimminsdale type where galena occurs in situ. It was formerly worked here.

A mile to the east the Lower Keuper Sandstone thins out. In the boring to the north (District I), at Piper Wood, No. 1 (230 O.D.), Carboniferous Limestone and Millstone Grit were met with, with no Red Marl or sandstone, but in No. 2 there was 46 ft. 6 in. Probably the galena came from some such concealed ridge of limestone, and doubtless the Lower Keuper was derived locally largely from Bunter pebble-beds and the Millstone Grit, the grains in each having some considerable resemblance.

Further east, at Longcliffe Quarries, Red Marl lies horizontally upon the upturned edges of the syenite, with green and white skerry bands. In the top quarry there is much more Red Marl (10–20 feet) with an interbedded band of gritty brecciated sandstone or sandy marl. The fragments of weathered syenite are triangular or sharply angular or pentagonal in cross section, 1 × 3 inches; others are small, and make up a gritty paste. The marl and sandy matter are all composed of local rocks and are highly saturated with iron oxide. In the top quarry only a few bands of skerry run through the Red Marl on the east side. Along the west side in the top and bottom of the top quarry they are more frequent and closer, approximating to thick but laminated beds of sandstone, probably equivalent to the Bardon skerry. They dip away to the south-west on that side. In the second quarry at a lower level on the west side thin beds of flaggy marl and sandstones and an interbedded thick sandstone with larger grains of quartz and felspar, etc., dip away gently on either side from the dome of granite, and when covering it they reunite and form a continuous but slightly undulatory band, following the dome structure above, but becoming horizontal away from the latter. The dome strikes north-west by south-east, and is on the line of the anticlinal axis. The marl beds are identical on either side of it, and merge into a thick white band at one point, as at Bardon and Hathern (in the Red Marl), of kaolinized minerals. A similar structure is seen at Enderby, which is a continuation of this axis, where the Trias follows the dome structure in a similar manner. Along the east side of the quarry skerry bands are aggregated into a thickly laminated bed which lies just over the syenite, with an even more or less horizontal bedding. Ripple-marks occur on more than one side of the flags of skerry, bluish in colour here, and their direction is in the upper ones north-west by south-east, in the lower north-east by south-west. These beds belong to the waterstones.

At Forest Gate Keuper Marl covers the roofing slates, and at the base are pebbles of quartz and breccia lying on the upturned edges of the slates.

Turning to the western boundary again, in the Whitwick Shaft (530 O.D.) 191 ft. 3 in. Red Marl and sandstones lie over the thick bed of dolerite, with white sandstones 3–4 feet thick and Red Marl with waterstones. At the Coalville Waterworks boring (537 O.D.), 300 yards south of Whitwick Waste Farm, there were 113 feet of drift, 47 feet of Red Marl, and 100 ft. 10 in. of Lower Keuper Sandstone, overlying dolerite, green in colour. The beds in this section were very abnormal, being purple in part, with fine breccia like some Permian and Upper Carboniferous types.

At Bardon Hill, in the third quarry from the bottom on the south side, there is a V-shaped gully filled with Red Marl and angular blocks of the local rocks, overlaid by a horizontal band of Red and Yellow Marl, rather gritty, and, like the scree, full of fragments of local rocks. At two points yellow bands run down at right angles to the others in a vertical manner. The gully trends north-west by south-east, a similar gully being seen in section on the north side. This coincides with the ripple-marks.

In the fourth quarry [1] from the bottom, on the south side, horizontal

[1] Along the top of this quarry run two beds of skerry which above show white marl made up of kaolinized minerals at 800 feet.

bands of Red and Yellow Marl lie directly upon the older rocks. The lighter sands are quite yellow, others distinctly ferruginous and sandy. Some dark-red bands are full of local fragments of rock, often coated with lighter marl and manganese. In the cutting from the south the Keuper dips away to the south-west. A fault traverses the north side west and east. In the fifth or old top quarry in the centre of the east face there are cracks running vertically down through the old rocks filled with Red Marl at 880 feet. Horizontal beds of Red and Yellow Marl recently exposed to the north rise from the floor of the quarry. All the joints of the rocks right up to the top are stained with Red Marl. The beds in situ resemble those at a lower level and contain much local rock, and are much browner in tint than further off. W. Keay and M. Gimson have remarked upon the extraordinary height to which these beds rise above the surrounding country, the highest Trias in Britain, and add that it must have been deposited from a much higher altitude than 880 feet, and this would mean the total submergence of Bardon Hill. The beds dip 1°–3° to the south-east, and taking into consideration their distance from the Rhætics at Leicester there must have been a thickness of 200 feet of Red Marl above the present level. In the new quarry on the north side the newly-exposed surface of the rocks here is untouched by wind action and presents a well-preserved surface. Messrs. Keay and Gimson were unable to find any such traces where, as one would expect, the old shore-line here once was.

Along the road from Copt Oak to Charley Lodge there were formerly pits in the Red Marl with red clay above of glacial origin (700 feet). In a field 400–500 yards on the north-east the Red Marl contained regular white soft sandstone horizontally bedded. The valley between Copt Oak and Charley is filled with Red Marl in which a similar sandstone occurs, the same as the skerry at Bardon.

To the east a boring at Newtown Unthank (280 O.D.) showed drift 8 ft. 6 in., Red Marl 211 ft. 10 in., Lower Keuper Sandstone 155 ft. 3 in., and 242 ft. 2 in. Coal-measures. At Botcheston in an old pit a skerry crops out in the brickyard, which is probably on the same horizon as the Orton-on-the-Hill Sandstone.

At Kirby Muxloe, Barron Park, a boring showed soil and drift 36 ft. 11 in., Red Marl 80 ft. 5 in., and igneous rock (augite syenite) 1 ft. 2 in. The Red Marl is bleached with organic matter and contains grey markings traversing the rock in vertical and diagonal lines, due to acids in solution which have deoxidized the marl.

The Red Marl is exposed near the Holy Well at Ratby not far from the Roman Camp, and here presents a sandy character as at Thurmaston. In the brick-pit at Glenfield Drift overlies Red and Green Marls, used for brick- and tile-making, similar to the beds seen at Groby.

A conglomerate lies near the base of the Keuper in the Groby quarries. There is also much scree. At the Dowery Quarry variegated bands dip away from the syenite, and in the Large Sheet Hedges Quarry horizontal bands lie over the syenite at various points with a scree at the base. These beds are also extremely sandy, less marly than in the surrounding district. It is certain that to some extent the horizontal appearance around these knolls of older rock is partly illusory, but allowing for the angle of rest of beds lying upon inclined slopes this radial dip is a natural feature of aqueous deposits. In the Ansty Paper Mill boring (225 O.D.) 70 feet of drift and 117 feet of Red Marl and gypsum, higher up in the series than the last sections, was met with.

Several trial holes on the Beaumont Leys estate penetrated the Red Marl at high elevations. Where the Great Central Railway crosses the valley to the east sections in Red Marl are to be seen, and west of Leicester Abbey old pits in the field show 10–15 feet of sandy Red Marl with gypsum bands. In the Ansty Lane the Red Marl is cut through by the stream. A sandstone upon the same horizon as the Dane Hill Beds is seen to the north at Birstall, but makes no marked feature, and in this direction it is only where the River Soar has excavated its broad and deep valley that it reappears to any great extent.

Turning to the Red Marls in the Soar Valley just north of Leicester, at the Star Brick-works at Thurmaston, 12–15 feet of Red Marl, 4 feet of which is spotted with green, much harder at the base, is exposed. The basal marl is more calcareous and resembles that of No. 13 at Barrow's pit (east of the Midland Railway) or No. 6 Vass's pit, irregularly bedded and less nodular. In the last 4 feet the green patches are irregularly distributed in more or less parallel bands here and there, uniformly elsewhere. A loose piece of sandy marl contained casts of Crustacean or Annelid tracks, perhaps glacially derived from the Dane Hill Series. The nodular concretionary marl at the base is full of cavities and honey-combed, and is more impregnated with iron. The concretions are probably upon the same horizon as a gypsum band, and represent a further stage of the loose anastomosing veined patches, where there was insufficient sulphate and more carbonate of lime, so that no gypsum was precipitated. At the Thurmaston Pottery to the north a coarse-grained skerry crops out here, which finds its equivalent at the Thurmaston brickyard. But at the last locality it has thinned out, and is there just an ordinary skerry. At Gipsy Lane a hard pink skerry occurs at the base of the thick green band over the gypsum, but these are not equivalents. The skerry is even coarser than the Dane Hill Sandstone, which disappears east of the River Soar. It is intercalated in Red Marl, which is used here for making tiles and pottery, the marl readily lending itself to the lathe.

In the Thurmaston Brick-pits excellent glacial sections are to be seen over Red Marl and gypsum down to a depth of 27–40 feet. To the south the Red Marl is very sandy and highly ferruginous, easily breaking into sand. To the south again the anastomosing fibrous gypsum takes the place of the compact gypsum seen in the railway cutting, and there is about 2 feet below a layer of skerry. At the north end the compact gypsum is in isolated masses, as often happens at Gotham, with marl between. There is no appearance of subsequent formation, and it must have been formed originally in separate hollows or pans. The reticulating veins of gypsum at the south end present a marked contrast to this. It is rather higher, showing that the bed dips to the south-east. The Red Marl is similar to the lowest layer at Barrow's pit (west of the Midland Railway). The skerry band resembles the dolomite band at Vass's pit. Seen in section the anastomosing veins of gypsum terminate abruptly with broken ends, crossing and intersecting at all angles. Some larger veins stand out more prominently.

In a disused pit near the Victoria Road, Humberstone, 11 ft. 9 in. to 18 ft. 6 in. of Red Marl, with green marls and skerry and two bands of gypsum, is seen. The gypsum is here occasionally coated with selenite crystals. The ball gypsum contains cavities filled with Red Marl. One thin laminar piece of gypsum was embedded vertically in the Red Marl, with a pitted and decomposed surface. One piece had a line of oblique cavities at intervals on the uppermost part.

At the Gipsy Lane Pit there is a fine section from Rhætics downwards: 15 ft. 3 in. of Tea-green Marl, with seven nodular bands overlying Red Marl, skerries, and gypsum, 69 ft. 9 in. to 77 ft. 9 in., or nearly as deep as the Glen Parva section, but beginning lower down and so carrying on the sequence. Moreover, it is the nearest available section of these beds to Leicester. The Tea-green Marls are not so green as at Glen Parva. The same courses of nodular calcareous marly bands as at Glen Parva, where fish occur, are seen. The whole formation is much more calcareous. The supposed discolouring of the Tea-green Marls from red to green or grey does not obtain here, since the Rhætic beds are of no thickness. There is no bone-bed, and the Black Shales are not characteristic. The variegation of the Red Marls below the Tea-green Marl here is well shown. In fact, this is the best section in these upper beds. The Red Marl varies in colour from pure red to brown or chocolate. In places it is pink, especially where in contact with green or white bands. It is often coated with powdery oxide of manganese, and the faces of the nodular structure are spotted black with the same. The Red Marl is usually nodular, and at this horizon is seldom shaly or laminated. It does not assume a loose sandy character as at some adjacent exposures, except at the base. The red bands are parallel with the green or white, with some exceptions. The green bands are made up of marl or skerry, or gritty sandstone. There is a preponderance of these narrow bands alternating with the red bands at this horizon. One band is especially thick and well-marked at 10 feet (*circa*) from the top. It is on the laminæ of this that the ripple-marks seen in situ (north-west by south-east to north by south) occur. While the Red Marl consists very largely of fine quartz-dust, etc., and is but slightly calcareous, the green skerries, which also have a greater specific gravity, are much more calcareous, and the separate particles are larger and more varied in composition. Large grains of pink felspar, with others white and decomposed, are common. Many of these bands are largely dolomitic, and, as at Vass's pit, are full of cavities. The skerry bands show evident laminæ and lines of stratification, and are not nodular. There are lines along which the particles are graded into different sizes.

The gypsum is of four types—(1) thick-bedded, tabular, compact, often impure, and streaked with marl; (2) ball gypsum, plano-convex in form, spheroidal, pure, and very hard; (3) fibrous gypsum or satin spar, having the crystals vertically arranged; (4) selenite, having a typical crystalline form, often twinned, or in laminæ, or plates. The selenite is often encrusted upon the outside of the ball gypsum, and is stained a chocolate colour. The gypsum is white or yellowish-white, pink, or greenish, especially when traversed by Green Marl. The latter may under- or overlie a seam of gypsum. Fibrous gypsum passes laterally into ball gypsum, and often anastomoses. Pseudomorphs of salt crystals are abundant upon the surfaces of the green bands, varying in size from $\frac{1}{4}$ to $\frac{4}{8}$ inch across. They are associated with ripple-marks.

There is an interesting case of what may be regarded as undulatory bands of coloration, where a thick green band below the thick gypsum band exhibits a dip or syncline, transgressing a chocolate band below. The bedding is horizontal throughout, and this shows that coloration here, at least, is secondary to bedding. On the view that the green coloration is original and the red due to percolation by influx of chalybeate water, as held by Dr. Moody, the red coloration of the lower band must have been applied from below upwards, and the dip in the green colour would be due to the different porosity of the latter, or its composition influenced by its greater specific gravity.

The ripple-marks trend north 20° west. They are practically upon the top of the thick green band near the top of the section. This is not seen elsewhere,[1] for at Glen Parva the floor is upon a layer of pink granular gypsum. In some parts the top is covered with small slabs ($1 \times 1 \times 2$ inches) of this granular salmon-pink variety. At others there is a peculiar hard pink kind of skerry passing into greener marl with a pink layer of gypsum below. The hard pink layer is semi-crystalline, and resembles the band at Vass's Brickyard, into a form of which it passes, containing here and there hollow cavities, and in large measure also dolomite. The steeper side of the ripples faces north-west, so that the direction of any current would be at right angles, i.e. from the south-west.

At Vass's brickyard, a little to the north, a section 14 ft. 4 in. to 26 ft. 6 in. exhibits Red Marl with three Green Marl and skerry bands, and a floor of gypsum. The marl here is not so hard as at Gipsy Lane, being more sandy. I found some pseudomorphs of salt crystals on what were apparently Red Marl slabs, but subsequent examination showed that it had been stained red. Mr. Whitaker, I believe, has found pseudomorphs on Red Marl. The junction of the red and green bands is irregular, with concretionary masses. The dolomite with hollow cavities contains casts of what might be taken for organic structures, but they are too indefinite to base any decided opinion upon as yet. A curious skin is to be noticed upon the exterior of some of the gypsum, which lies here nearer the surface than at Gipsy Lane, and this must be due to recent chemical change, just as another block of ball gypsum was pitted and fretted.

In Barrow's pit, east of the Midland Railway, 33–46 feet of

[1] Except near Gotham.

Red Marl and Green Marl and skerries with five gypsum bands are exposed. In the top band the gypsum passes laterally into Green Marl. The third band thins out to the north. The second band is fibrous. Between the north and south end of this pit the extent and number of the gypsum bands is very variable. It represents the lower part of the Gipsy Lane section. Bed 13 is more massive, and jointed. Below bed 11 the marl is exceedingly hard, and impregnated with selenite crystals, like some Upper Rhætic shales. The skerry in No. 10 is dolomitic and full of drusy cavities, as at Vass's pit. The gypsum varies greatly in colour from white to greenish-white, yellow or orange to salmon-pink. The upper surface may be covered with spheroidal concretions or is even. The satin spar is often tinged pink. In this and other cases there is abundant evidence that the red colour is secondary. The ball gypsum is exceptionally well developed, showing the plano-convex structure admirably. The masses are isolated, but arranged in horizontal layers.

In Barrow's pit, west of the Midland Railway, 16–28 feet of Red Marl and Drift is seen in section. The Red Marl resembles that of the Belgrave Brick Company's and Star Brick Company's works, and is stiff and tenacious down to the floor, which is the same as the base of the Belgrave Pit. The bedding is regular and uniform, each bed retaining the same characteristics throughout, and no better evidence of aqueous deposition could be desired than so clear-cut a section. If the variegated beds convey this impression by their regularity and horizontal bedding, a section such as this, without them, adds additional emphasis to the matter. About 12–16 feet of Red Marl below soil and river-gravel is exposed at the Belgrave Brick Company's pit adjoining. The Red Marl is the same as that at the Star Brick Company's works, and is very nodular, splitting into rounded nodules, and contains much manganese. Spots of Green Marl occur in the Red at the Star Brick Works. This pit is continuous with Barrow's pit west of the Midland Railway, from which only a bank separates it, and in the latter the floor is used for growing cereals, which do well on the sandier beds.

On the west side of the River Soar the coarse sandstone representing the Dane Hill Sandstone is seen in the Cossington district in the Fosse Road above Lewin Bridge, in the lane leading thence to Cossington, and the ridge flanking the Soar Valley on the west is caused by the feature it forms. By the River Soar west of Syston sandy Red Marl with skerry crops out in the river banks.

From Chellaston southward gypsum bands can be traced by Gotham Sileby to Queniborough and Thurmaston, and south of Leicester at Blaby. It is found in a pit east of Syston on the Queniborough and Barkby road, where a very uniform thickness (30–40 feet) of Red Marl with few green bands representing the lower part of the Gipsy Lane Pit is to be seen.

From Gipsy Lane northward the Tea-green Marls can be traced nearly to the fault north of the Humber Stone. North of Barkbythorpe they are only seen just here in a few isolated exposures.

A coarse sandstone of the Dane Hill Sandstone type is seen near Rothley. In the Great Central Railway cutting at the station at the bridge under the road to Rothley sand terminates abruptly against Keuper Marl, a feature noticeable in these drift sands. The Upper Keuper Sandstone at Ratcliffe is seen in the village, where it is thicker than at Rothley. It crops out in the west bank of the Wreake, south of the mill, where it is intercalated between sandy Red Marl and Green Marl. At Shipley Hill long barrow the marl is evidently made ground.

At Sileby there is an interesting section of Red Marl at the Phœnix Brick-pit. The section is 61 feet thick. In bed 2 there are irregular markings, chiefly vertical, of Green Marl running down into the Red. Irregular green patches are seen in the bed 3 also, and in beds 4 and 29. There is a good deal of skerry at certain horizons, which is useless for brick-making. This pit is especially interesting, as it exhibits well the irregular deposition or variegation of the Red and Grey Marls. Long streaks of Grey Marl depend from a horizontal layer into the Chocolate Marl, as though having gradually trickled down or fallen into it when liquid. This never happens, on the contrary, in an opposite direction, i.e. Red Marl never exhibits this arrangement when overlying Green Marl. This seems to favour the diffusion column idea, and that the Grey Marl is heavier than the Red. When the Red Marl is irregular at the base it takes a concave form, which indicates an overlapping of the red colour upon the grey, irrespective of bedding.

There are five pits in the adjoining Albion Works in this series of workings, all of which exhibit the same section as at the Phœnix Works (upper part). In two, one to the north of the cutting and bridge, there are instances of Red Marl showing a saddle-like roll, as though indicating a local instance of a subaqueous dune. In the last case one is seen on the east face and another on the north face, and it is possible that the two were connected by a circular sweep which would give roughly a south-west and north-east direction for the force moving it. In the other quarry, seen from the railway, two such rolls occur in the Red Marl lying over each other on the north face, and the intervening Grey Marl follows the same course. Others occur on the east and south faces. They are practically all at one level, and have not been noticed elsewhere. This district has been much disturbed, and it is possible these undulations have some local connexion with the same phenomena or perhaps colour distribution.

At Mountsorrel on the opposite side of the Soar, in the large quarries along the north-west faces near the top, Trias fills the hollows. It lies quite horizontally against the granite, with no radial dip. Blocks of granite lie at the base of the marl in the hollows, as do the Charnian rocks at Bardon. Some are rounded, but not all.

Upon Castle Hill the blocks of granite are quite angular on the south and east sides; but along the north and west sides, or from half-way along each side of the last, they are smoothed and polished, doubtless by wind action. The extent of the polishing is not very marked considering their exposed nature, nor could the period at which they were polished be determined from the overlying deposits. Where covered at all they are covered by drift.

Professor Watts, who described the wind-polished rocks at Hawcliff Hill, not now visible, has remarked that where the Red Marl forms a junction with the isolated bosses of granite the sides are very precipitous, showing that they formed "peaks and nearly vertical cliffs in the Triassic sea". Wells sunk in the Keuper close to the granite go down to a depth of 100 feet.

At Nunckley Hill the Keuper Marl is covered by Boulder-clay, and on the west side it abuts against the granite, large blocks lying in the Red Marl "as if they had fallen from a cliff during its deposition". The viaduct is built upon Red Marl lying against the granite. In the valley west of Quorndon the Great Central Railway is in Red Marl up to Rusheyfields Lane. There is a sandstone in the Red Marl at Buddon Wood full of drusy cavities, which is probably the Dane Hill Sandstone. Here also the edge of the granite is very steep where the Red Marl abuts against it.

Between District (1) and Loughborough the Red Marl is much covered by drift. At Loughborough Lane there is a scree at the base of the Red Marl overlying the older rocks.

In the Swithland Slate Quarries, as noted by Jukes, the Red Marl rests horizontally on the upturned edges of the slates, and the bedding of the Red Marl follows at the base the uneven surface of the slates, ascending over the rising portions, and in the hollows following the depressions. Harrison came to the correct solution that this conformity of the marl with the irregularities of the floor on which it lies is due to the natural manner in which deposits repose on slopes and hollows.

At Woodhouse Eaves Red Marl penetrates the valleys in the Charnian rocks, lying in the hollows. As on the north and at Copt Oak, a skerry or white sandstone probably representing a band low in the marls forms a floor in the pits where the marl has been used for brick-making, now disused.

In a small cutting in Red Marls and green skerries pseudomorphs of salt crystals occur at Beaumanor. At Quorn Station the Red Marls to the south are very sandy, as nearer Leicester.

George Maw, 1868, first noticed that "the Red Marls of Charnwood Forest dip away in every direction from the high ground of the older rocks towards the surrounding level plain. But I was much struck with the fact that the direction and amount of inclination seemed to be less related to the entire mass of the high ground than to its details of contour. Another noticeable feature of Charnwood Forest is the relation of the areal outline of the Red Marls to the surface contour of the older rocks rising above them, long winding tongues of the red beds running up into the ancient valleys of the high ground, the contour of the exposed portions of which is entirely in harmony with that of the bottom of valleys buried beneath the remnants of the later deposit". He remarks, further, on the antiquity of the hill and valley system, the absence of marine erosion, and the antiquity of the ancient lines of waterflow (pre-Triassic).

(*To be continued in our April Number.*)

REVIEWS.

I.—The Stratigraphy of the Chalk of Hants. With Map and Palæontological Notes. By R. M. Brydone, F.G.S. 8vo; pp. 1–116, with 3 plates and coloured map. London: Dulau and Co., 1912. Price 10*s*. 6*d*. net.

THE publication of this work, comprising the results of research extending over more than twenty years, provides a notable addition to the literature of the Chalk zones. At the onset we must congratulate Mr. Brydone on the completion of the truly prodigious work of zoning 1,052 exposures of Chalk in Hampshire. He has succeeded, moreover, in producing from his results a very fine zonal map on the 1 inch scale, clearly a task beset with many difficulties.

Treatises on the Chalk of Hampshire, as Mr. Brydone remarks, are not numerous. On this account we could wish that in his brief bibliographical notes he had referred, as in a previous publication, to the excellent work on Chalk geology carried on since pre-zonal days by the Winchester College Natural History Society. Its latest publication [1] (issued since the appearance of Mr. Brydone's book), dealing with the various divisions of the Chalk, and giving lists of fossils and sketch-maps, affords a conspectus of the Chalk round Winchester that could not fail to be of great value to any student unable to consult more compendious essays. The present volume must be regarded as an amplification and completion of the previously published work by the author and Mr. Griffith on *The Zones of the Chalk in Hants*. As regards some views and terminology therein adopted, Mr. Brydone in his first chapter suggests sundry modifications. His researches have brought forward many interesting points in connexion with the *mucronata* zone, which, by the way, has been discovered in a new district near Dean. It is found that in Hampshire the ranges of *Belemnitella mucronata* and *Actinocamax quadratus* are commerged for at least 20 feet, the advent of the former coinciding with the appearance of marl. As Mr. Brydone says, "the general result is to administer . . . a severe shock to the doctrine of the infallibility of *B. mucronata* as a zonal guide."

Some changes are made with respect to the *quadratus* zone. It is proposed that the sub-zones of *Offaster pilula* and *Echinocorys scutatus*, var. *depressus*, should be separated under the name of the zone of *O. pilula*, but that this should still be divided into the sub-zones of abundant *O. pilula* and *E. scutatus*, var. *depressus*. The familiar *Rhynchonella cuvieri* has disappeared without apology or explanation from the zonal terminology in this book, *Inoceramus labiatus* being used instead as the index-fossil.

It may be highly desirable and may constitute an advance on the lines of present research to establish sub-zones (each in itself, of

[1] *Geological Notes on the Chalk of Hampshire, with Hints to Collectors*, by C. Griffith, M.A., F.G.S. 43 pp., with sketch-maps. Published by the Winchester College Natural History Society, 1912.

course, satisfying the definition of a zone), but original standardizations of zones should be retained. Nor does it seem desirable that any separate index-fossil should be invested with a denotation differing from that already generally accepted. Mr. Brydone is careful to define his terms, but it must be borne in mind that the arbitrary limitation of zones by successive workers tends to produce hopeless confusion in zonal nomenclature. And here it may be observed that only on the assumption that the boundaries of the author's zones differ from those given in previous publications on the Chalk is the difference in coloration in the map to be recommended.

One desirable feature of Mr. Brydone's work is the employment of a standard of values in referring to the occurrence of species by such terms as 'abundant', 'frequent', 'scarce', and so forth. Doubtless much ambiguity has from time to time been caused by the mode in which chance records have been interpreted and used as premises for more important generalizations. This attempt, therefore, at greater accuracy is to be welcomed.

A consideration of the general structure of the area dealt with occupies more than twelve pages; but extended reference to this section is obviously precluded here. In discussing his methods of mapping the author acknowledges the helpfulness of the work of the Survey in having traced the salient boundary-lines. One inherent difficulty in the author's undertaking was the lack of sections showing the complete thickness of zones. A brief but well-considered description of the locality of each exposure is given in a list, which groups the localities according to horizons, each exposure bearing a number corresponding to one on the map—a scheme that has been found advantageous in works with similar aims. For the reception of records not included in Messrs. Griffith & Brydone's book a supplementary table of fossils has been prepared. This table is prefaced by observations of which some seem to call for comment; and the author has done good service in abstaining from the use of specific names that have no definite meaning (e.g. *Serpula plana*). Mr. Brydone finds himself unable to see any justification for the record of *Micraster præcursor* as a separate species, a view that will come as a surprise to many Chalk workers. Such a point, in our present state of knowledge, must be a matter of opinion; but the fact remains that the group of *M. præcursor* as defined by Dr. Rowe is found very acceptable by workers in other parts of the country.

A chapter of palæontological notes is found at the end of the book. Here three new varieties of *Echinocorys scutatus* (vars. *elevatus*, *tectiformis*, and *cinctus*) are described, each occurring at a definite horizon. A sequence in the dominant shapes and sizes of *Offaster pilula* has been traced; and two new forms of *Bourgueticrinus* ('forms 6 and 7'), both of stratigraphic value, placed on record. The determination of these as auxiliary guides is extremely useful. Some attention has been bestowed upon Sponges, descriptions being furnished of four new species of *Porosphæra* and two of *Retispinopora* (new genus = *Spinopora* partim). *Plicatula hantonensis* is also among the new species described.

II.—The Moorlands of North-Eastern Yorkshire: their Natural History and Origin. By Frank Elgee, F.G.S. 8vo; pp. xvi, 361, with 70 plates and text-illustrations, geological maps and sections, and maps of the Moorlands. London: A. Brown and Sons, Ltd., 5 Farringdon Avenue, 1912. Price 12*s*. 6*d*. net.

VOLUMES, large and small, descriptive of the scenery and antiquities of various districts and counties in England, are by no means wanting, and the attractions of the Yorkshire Moorlands have been portrayed by many distinguished writers. The present work is, however, not merely descriptive, illustrated as it is by many excellent photographic plates by the author, with some by Mr. Godfrey Bingley; it is also explanatory, dealing with the geological history of the Moorlands, the disposition of the strata, and the sculpturing of the hills and dales, with the origin of the moors and distribution of their plant-life, and the relationship in general between the botanical, zoological, and geological features. In short, it is a philosophical work, treating the subject from what is now termed the Ecological point of view.

After referring to the previous literature on the district, the author gives a short account of some of the human aspects, describing the old roads, the ridgeways, the causeways (which are often paved with stone), the standing stones, circles, and crosses. Reference is made to pit-dwellings, some of which, however, like the Killing-pits near Goatland, were probably old ironstone workings, while some holes were evidently due to the removal of slabs of stone, and others have been caused by the dissolution of calcareous strata.

The highest ground in the Moorlands is at Burton Head on Urra Moor, 1,489 feet above sea-level. The moors are almost exclusively clothed with heather, but some are covered with much cotton sedge and grass. The author discusses the formation of the moorland soil, which comprises surface-peat, resting on about 10 inches of peaty sand, with usually at the base a hard ferruginous layer, generally not more than an inch or two thick, known as the Moor Pan. This layer has tended to prevent the growth of trees; so also have the strong winds on the higher and more exposed moorlands. Evidence of woods of oak and birch are, however, met with in some of the glacial slacks or overflow channels, where tree stumps are found beneath coverings of peat which destroyed the woodland. In some instances the destruction of the timber was probably accelerated by man. The vegetation on the moorland slopes differs from that on the summits, and the author points out that the aspect, inclination of slope, amount of downwash, and absence of thick peat, have influenced the distribution of the plants.

The effects of the Ice Age are duly considered with especial reference to the researches of Professor P. F. Kendall. The higher uplands afford no evidence of glaciation. The Cleveland Hills on the north presented an impassable barrier to the ice-sheets, so that sundry moors, though surrounded by ice, were free from any covering of it, and free therefore from drift. The author maintains the view that the driftless areas supported vegetation during the Ice Age, the plants including most of the northern species. In discussing this subject he naturally refers to the labours of Mr. Clement Reid.

In the description of the geological formations, and the record of events which have led to the present physical features, the work of Mr. C. Fox Strangways is fully appreciated. It is pointed out that the wide moors could never have been evolved unless the strata were suitable, but the pure siliceous soils, which are mainly on the Estuarine Series, and to a less extent on the Kellaways and Corallian Beds, proved favourable to the growth of heather. There is a good view of the Cheese Stones at Baysdale, formed of Lower Estuarine Sandstones, which occasionally exhibit "atmospheric pot-holes", cavities that increase from mere depressions to two or three feet in diameter, and sometimes resemble fonts. They are attributed by the author to the action of the atmosphere, and of the wind acting on small fragments of rock. Hollows of this kind in other districts have been termed rock-basins.[1] The isolated rock-masses and most of the so-called boulders on the high moors are relics of strata in situ or not far removed; they have not been distributed by glacial action, but many have channels or grooves due to meteoric abrasion.

In giving short descriptions of the several formations the author notes the plants of the Oolitic coal-field, in which the moor coal occurs. The subject is illustrated by various views, those of the Kellaways Beds being fine examples. A plate of coloured geological sections indicates the general geological structure, and a very clearly printed geological map shows the distribution of the formations. The Cornbrash, which has but a narrow outcrop, is not separately coloured, but its position is pointed out (p. 192). Here it may be remarked that the geological map, while "based upon the Ordnance Survey Maps", is the product of the Geological Survey.

The author describes the main structural features, some due to the elevation and folding at the close of the Jurassic period and prior to the Cretaceous overlap. The covering of Chalk was removed in Eocene and Oligocene times, and it is regarded as probable that the features then produced belonged rather to a plain of marine denudation than to a subaerial peneplain, as the occurrence of scattered pebbles of flint and quartzite appears to indicate a former (possibly marine) Tertiary deposit. Disturbances accompanying uplift in Miocene times accentuated some of the earlier folds, and tilted the strata into their present positions. The author discusses the relation of the synclines and anticlines to the present features, including the formation of outliers and inliers. In describing the origin of the dales he points out that most of them lie outside the limits of glaciation, and are to be attributed to the ordinary action of rain, frost, snow, springs, and rivers, influenced by the dip and lithological characters of the strata.

The later portions of the volume contain accounts of animal life on the moors, and the author refers the mammalian remains of Kirkdale Cave to pre-Glacial times. This is not in accordance with evidence elsewhere, as in the older Thames Valley drifts, where the fauna is later Pleistocene; but it may be taken to mean that the remains are

[1] See D. Mackintosh, Geol. Mag., 1867, p. 398.

pre-Glacial to the district. The final chapter contains a useful summary of the author's observations and conclusions, and it is followed by a good index.

III.—The Lost Towns of the Yorkshire Coast, and other chapters bearing upon the Geography of the District. By Thomas Sheppard, F.G.S. 8vo; pp. xviii, 329, with 156 illustrations. London: A. Brown and Sons, Ltd., 5 Farringdon Avenue, 1912. Price 7*s*. 6*d*. net.

THE particular portion of the Yorkshire coast described in the work before us is that of Holderness, which extends 35 miles between Bridlington and Spurn Head, and also includes the northern Humber shore westwards to Hull. These two tracts of coast, however, exhibit some conditions of a totally different character. Along the open sea-coast the average annual waste of land is 7 feet, or locally from 4 to 9 feet; while on the borders of the Humber, although there is evidence of the loss of a number of villages, large tracts of sediment have accumulated during a period of forty-five years, and more than two thousand acres have been reclaimed by means of embankments, and are now under cultivation. Indeed, the author remarks that "as years go on the Humber is confined to narrower and narrower channels".

In the more difficult task of estimating the amount of land which has been lost, the author, who is a keen observer, has made himself familiar with all the physical features and geological formations of the district, and with the processes of destruction of the cliffs. He has, moreover, had the benefit of a number of cliff-measurements, and of consulting documents, plans, and charts, many of which have not previously been studied in connexion with the waste of the land. He has therefore been able to deal more fully and precisely than others have done with the results of the coast erosion, and his work is profusely illustrated with maps, plans, charts, pictorial views of the coast, reproductions of old engravings of lost churches and other buildings, and objects of archæological interest.

A brief and to some extent hardly necessary account is given of the geological formations of the Yorkshire coast, from the Lias to the Chalk and Drifts, as the Drifts alone are of importance in reference to the physical features of Holderness and to the nature of the cliffs. The land, which includes considerable areas below sea-level, is formed in part of Alluvium, but mostly of red or purple Boulder-clay. It is a low-lying hummocky tract of clay and gravel, in which formerly there were many meres, but only that of Hornsea remains.

The sea-cliffs, 10–50 feet high, are thus formed mainly of clayey material which is readily eroded, the various subaerial forces acting with the sea in the processes of waste. A view of the cliffs at Kilnsea shows the way in which the sea is assisted in its work of destruction by the drains leading to the cliff-edge and softening the clay.

Apart from the visible waste, it has been pointed out that much erosion is going on below low-water level, many miles out to sea, and at depths of from 5 to 10 fathoms. It is estimated that since

Roman times about 83 square miles of land have been lost, equal to a strip 2½ miles in width along the Holderness sea-coast.

The author describes the changes that have taken place in the neighbourhood of Hull, and points out that the once flourishing sea-port of Hedon, to the east, is now 2 miles distant from the Humber. To the south-east the large tract of Sunk Island and bordering ground have been reclaimed, but a number of villages have been lost between that island and Spurn Head. Full particulars are given of these and other lost villages and towns along the Holderness shores. The author then briefly describes the origin of the Humber mud, the natural history of the district, and the extinct animals, including the Mammoth and others among those pre-Glacial in the area. The early and later history of the people and their works, the administration, agriculture and other industries receive attention, and finally there are notes on the climate and rainfall. A good index completes this able record of the natural and artificial changes that have taken place in the district.

IV.—Soils and Substrata.

The Geology of Soils and Substrata, with Special Reference to Agriculture, Estates, and Sanitation. By Horace B. Woodward, F.R.S., F.G.S. 8vo; pp. xvi, 366, illust. London: Edward Arnold, 1912. Price 7*s.* 6*d.* net.

THIS is exactly the sort of book one is always wanting, and it could scarcely have proceeded from the hands of one more competent than Mr. Woodward. It is not a book to criticize, but to describe, and we content ourselves by offering to our readers a sketch of the various points treated.

After a preliminary outline of geology, the relations of rocks to the form of the ground and scenic geology in general, the value of geological maps, and the advantages of such knowledge in agricultural research are pointed out, and definitions of subsoils and substrata are given. The author then treats of weathering, subsidence, surface-soils, and climatic and other physical conditions affecting the soils and agricultural operations. Passing on to chemical and mechanical constituents of soils, plant foods, and bacteria, he discusses the fertility and barrenness of soils, drainage and irrigation, water meadows and manures, dealing especially with forests, woodlands, orchards, market gardens, and vineyards. Geological considerations concerning estates, mineral rights and economic materials, sites for buildings, disposal of waste water, farm drainage and refuse, sewage farms, cemeteries, water supply, and ponds, are all dealt with in turn, and the remaining chapters are devoted to sketches of the various geological formations met with in England and Wales.

The subject is dealt with from the practical point of view. Under the term 'soils' are included the subsoils and surface-soils, the term 'substrata' being, for the sake of convenience, applied to the igneous as well as to the various sedimentary and metamorphic formations from which the mineral constituents of the soils are directly or indirectly derived. Prominence is therefore given to the chief mineral and lithological characters of the formations and to their economic products, little being said about their method of origin, and less about their life-history.

This book should be found of great service to farmers, builders, and estate agents, and its value is considerably enhanced by the numerous references to the more advanced and special literature on the various subjects, and the excellent index.

V.—The Distribution and Origin of Life in America. By Robert Francis Scharff, Ph.D., B.Sc. 8vo; pp. viii, 497, with 20 figures [maps]. London: Constable & Co., Ltd., 1911.

FOLLOWING on the delivery in London of the "Swiney Lectures on Geology" five years ago, Dr. Scharff published the now well-known *History of the European Fauna*. The present volume contains the substance of his second series of lectures on the "Geological History of the American Fauna", but the subject-matter has been amplified and enlarged. It should be mentioned that owing to unusual circumstances notice of this valuable book has been somewhat delayed.

Each one of Dr. Scharff's fifteen chapters deals with a separate region, e.g. Greenland, north-eastern North America. The wealth of information contained in this book, which is furnished with twenty helpful maps, is conveyed in an interesting fashion; and reference to the numerous authorities quoted throughout the book is made in a fairly complete bibliography at the end.

As might be expected, the problems connected with the Ice Age form an important part of this book. There is ample biological evidence now available to show that the formation of two land bridges, connecting North America with Europe on the east, and Asia on the west, closed in the Pacific and Atlantic Oceans on the north about the same time. Hence the warmer climate in Pre-Glacial times must be attributed to the fact that the Arctic Ocean received more abundant warm currents then than now. The idea of a former land-connexion joining Scotland, Iceland, Greenland, and Labrador, put forward on several independent grounds, has its strongest confirmation, Dr. Scharff thinks, in the geographical distribution of *Helix hortensis*, a typically West European species. This snail has been found in the mainland of Europe, Ireland, Shetland, the Faröes, Iceland, South Greenland, Labrador, the islands off the north-west coast of North America, and part of the opposite mainland; and it has lately been collected from the Pleistocene of Maine. That geological evidence as to the date of this land-connexion will ever be forthcoming seems far from probable.

Among other instances of former land-connexions adduced in discussing the distribution of various animals are the mid-Atlantic, the South Atlantic, and the North Pacific. The account of the fauna of the Galapagos Islands is particularly interesting and important. The author inclines to the view of Professor Baur that this archipelago represents the remnants of a sunken land-mass once uniting the West Indies, Cocos Island, and Central America, and is not, as Darwin held, of volcanic origin.

In this book, however, we find so vast an amount of detail that a consideration of its full merits is not feasible in the space at our disposal. It remains only to add that the volume must at once take its place as a standard work of reference.

VI.—Geological Survey of Scotland.

The Oil-Shales of the Lothians. Part I: The Geology of the Oil-Shale Fields. By R. G. Carruthers, based on the work of H. M. Cadell and J. S. Grant Wilson.—Part II: Methods of working the Oil-Shales. By W. Caldwell.—Part III: The Chemistry of the Oil-Shales. By D. R. Steuart. Second edition. pp. xii, 199, with 83 text-illustrations and 3 plates. Printed for His Majesty's Stationery Office, 1912. Price 2*s*. 6*d*.

THE former edition of this work was published in 1906; and that the public appreciate a memoir having important practical applications is shown by the issue of a revised edition. Owing to the death of Mr. Grant Wilson the geological part of the memoir has been revised by Mr. Carruthers, who has added much new information relating to the later boring operations and the extensive mining developments.

The Oil-shale Group occurs in the Calciferous Sandstone Series, and includes six important seams of oil-shale, interstratified with beds of sandstone, shale, fireclay, marl, and estuarine limestones. The Oil-shale Group, more than 3,000 feet in thickness, forms the upper division of the Calciferous Sandstone Series; the lower or Cementstone Group has not at present yielded any oil-shales. The distribution of the strata is well shown on a colour-printed geological map, on the scale of an inch to two miles.

Among some of the new points to which attention is directed, are the separation of the Barracks and Burdiehouse Limestones; the recognition of the zonal value of certain horizons, especially two bands of marine fossils, the Mungle and Pumpherston shell-beds, which have been proved to extend over the whole oil-shale field; and the demonstration that the teschenite sills are generally restricted to particular horizons, while the quartz-dolerite sheets are more irregular in their occurrence. A plate showing the most characteristic fossils has been added, together with notes dealing with their value to the mining engineers. Most of the longitudinal sections have been re-drawn and some new ones inserted, while the plate of vertical sections has been revised.

The accounts of the mining and manufacturing processes have been brought up to date by Messrs. Caldwell and Steuart. The products include naphtha, various oils, paraffin, grease, still coke, and sulphate of ammonia (for manure).

VII. Bulletins of the United States Geological Survey.—In this memoir, No. 492, Dr. G. F. Loughlin discusses fully the gabbros and associated rocks, covering a quadrangular area of about 102 square miles, at Preston in the eastern crystalline rocks of Connecticut. The rocks in question comprise one complex of metamorphic sedimentaries —quartzite, quartz-biotite schist, hornblende-schist, black pseudo-porphyritic schist, of the type to which Fischer gave the name of kinzigite in 1861, and dolomite, two intrusive igneous masses—the Preston gabbro and the Sterling granite gneiss, and the great Lantern Hill quartz, which is one of the largest quartz masses known, being 1¼ miles in length and more than 1,000 feet in maximum width. The nature of the folding and the metamorphic deformation is carefully considered. The Preston gabbro has two principal variations: (1) a coarse porphyritic rock with large poikilitic phenocrysts of diallage, and (2) a quartz-hornblende gabbro, the former constituting the greater part of the area. The paper is amply illustrated with maps and micro-photographs.

In Bulletin 509 of the United States Geological Survey Mr. Waldemar T. Schaller brings together a number of interesting mineralogical studies which have mostly appeared elsewhere. He suggests that the variability in the composition of the members of the rutile group is readily explained by the assumption that the group is an isomorphous mixture of rutile, TiO_2, cassiterite, SnO_2, and tapiolite, $FeO . Ta_2O_5$, and proposes to retain the term ilmeno-rutile to designate mixtures in which Fe, Ta, Cb, and Ti are present in quantity, but to reject such variety names as mossite, iserite, ainalite, and struverite. An examination of crystallized turquoise from Virginia showed the mineral to be isomorphous with chalcosiderite, and, since the formula obtained for the former was $CuOH . 6[Al(OH)_2] . H_5 . (PO_4)_4$, that of the latter should be $CuOH . 6[Fe(OH)_2] . H_5 . (PO_4)_4$. Crystallized variscite from Utah was found to correspond in composition to the formula $Al_2O_3 . P_2O_5 . 4H_2O$, and in physical characters to be similar to scorodite and strengite. Apropos of the new hydrous sulphate and phosphate of lead, hinsdalite, the relationships of the alunite-beudantite series were discussed. An investigation of minerals from Beaver County, Utah, brought to light a new hydrous sulphate of lead and copper, beaverite, which is related to no known mineral. A description is given of a curious new mercuric mineral allied to kleinite.

VIII. Mines' Department, Canada.—The Summary Report for the calendar year ended December 31, 1912, shows increasing activity in the work of this Department, and we understand that the annual programmes are arranged with the principal object of rendering practical public service in the interests of the country. This volume contains the usual synopses of investigations, as well as the chemical, statistical, and essay reports, and statements from the Fuel-testing Station and the Metallurgical Laboratory. The investigations connected with the Canadian peat fuel industry are now almost complete, and have already been successful in their aims; and the establishment of a metallurgical research laboratory is of great practical importance to the department.

Among the preliminary reports on field-work may be mentioned those on the building-stones of the Maritime Provinces, the nickel industry (with special reference to the Sudbury region), and copper In the Sudbury nickel-field an experimental magnetometric survey was made, and the results show the magnetometer to be of signal assistance in such work. There are two appendices to the volume, one being a preliminary report on the mineral production of Canada for 1911, and the second an account of the explosive industry. A magnetometric map of a small area in the Sudbury nickel district and plans of the new headquarters of the Mines Branch are included among the illustrations.

From the same Department we have received also a detailed statistical report (145 pp., 10 plates, and numerous illustrations) on the utilization of peat fuel for the production of power. This is a record of experiments conducted at the Fuel-testing Station, Ottawa, 1910–11, and is divided into two parts: first, a description of the Körting producer-gas plant and cleaning system, with complete detailed records of trials and tests; secondly, a description of the alterations made to the plant, with similar records taken after alteration.

IX. University of California Publications.—From the Geological Department of this University we have received Bulletins 6–8 of vol. vii. Bulletin 6 is by Mr. C. L. Baker, on the physiography and structure of the Western El Paso Range and the Southern Sierra Nevada. The observations were made during a collecting reconnaissance for vertebrate fossils, and therefore do not aim at completeness. A sketch of the geography of the El Paso Range is given, and the rocks are seen to consist of a basement complex of metamorphic and plutonic rocks, a superjacent series of sedimentary and volcanic rocks, and the alluvium. The Ricardo erosion surface of the Southern Sierra Nevada is described, and it is seen that the southern Sierra front has not shared in the uplift that affected the country to the east and west.

A discussion by Mr. Bruce Martin on the fauna of the type locality of the Monterey Series in California occupies Bulletin 7. Details of location, stratigraphy, and lithology are given, and the various members of the fauna considered; and the general results support the correlation of the beds of the type locality with the middle and lower portion of Monterey Miocene of San Pablo Bay.

In the eighth Bulletin Mr. L. Kellogg describes the Pleistocene rodents from the Pollen Creek and Samwell Caves, and from the asphalt deposits at Rancho La Brea, near Los Angeles. These rodents are very persistent, for while they belong to genera still living, some of the carnivores and ungulates found with them are of genera now extinct. The rodent fauna of the caves does not accord with the present topography of the region, but that of the asphalt deposits is near to the existing fauna of the region and belongs to the Upper Sonoran zone. Two new sub-species are described: *Sciurus griseus fossilis* from the Samwell Cave and *Citellus beecheyi captus* from Rancho La Brea.

X.—Desert Conditions Past and Present.

Das Gesetz der Wüstenbildung in Gegenwart und Vorzeit. By Johannes Walther. pp. xv + 342, with 147 illustrations in the text. Leipzig: Quelle & Meyer, 1912. Price 12 marks.

AMONG those who have studied and described the characters of desert regions and have thrown light upon the conditions which prescribe their formation, Professor Walther occupies a prominent position. The volume which he issued in 1900 on the subject immediately attracted wide attention and some little controversy. With the publication of that work, however, his interest in the subject in no way waned, neither was his energy exhausted, and whenever time and opportunity afforded he seems to have found his way to Egypt and to have continued his observations and researches. The outcome is this, the second, edition, which represents the fruits of an almost continuous study of the subject for a quarter of a century. Written in an admirably easy style and amply illustrated with reproductions of excellent photographs, the book cannot fail to prove of extreme fascination and absorbing interest, not only to students of the subject, but to any reader with sufficient knowledge of the language to be able to read the book without difficulty.

The book is divided into four main sections. In the first is given a description of the desert regions as they exist to-day, and the effect produced by extreme heat and rapid evaporation is vividly brought home to the reader. In the next the author describes the erosion produced by the action of wind and sand, and by the torrential cloud-bursts which occasionally occur; the effect of weathering is very clearly visible in the case of the statues remaining in some of the ruined temples in Egypt. In the third section the author considers the formation and nature of the deposits which have resulted from the actions described in the previous section; and in the fourth and last he discusses the deserts of past ages, which have resulted in the immense beds of rock-salt and gypsum, containing the relics of a marine fauna, poor in species, but rich in individuals, found in various parts of the world. The value of the book is increased by the list of references and the complete index given at the end.

XI. The Dover Coal-field.—In the Geological Magazine for April, 1890 (p. 192), we announced, on the authority of Professor W. Boyd Dawkins, the discovery of coal in the boring at the foot of Shakespeare's Cliff. We read in the *Daily Mail* of February 4, 1913, that "coal from Snowdown Colliery, between Dover and Canterbury, was yesterday put on the local market by coal-dealers at prices slightly below those of imported coal. This is the first Kentish coal to be publicly marketed". The colliery is close to the Fredville boring and about 7 miles south-east of Canterbury.

It is interesting to receive at the same time an article on "The South-Eastern Coal-field, the Associated Rocks, and the Buried Plateau", by Professor Dawkins (Trans. Inst. Mining Eng., xliv, pt. ii, p. 350, 1913). He gives a plate, with three maps and two longitudinal sections, to show (1) the area of the South-Eastern

Coal-field, which extends from Dover to Deal, Wingham, and near to Ebbsfleet; (2) the structure of the ground between the borings at Dover and Ropersole, and between those of Fredville and Brabourne; (3) a map of the buried Silurian and Devonian rocks in South-Eastern England; and (4) a map of the coal-fields and tectonic folds of Southern England and Wales. He discusses the general structure of this southern area, and then gives details of the experimental borings, some of which proved the absence of Coal-measures, as at Chilham, in the valley of the Stour above Canterbury, and at Bobbing, near Sittingbourne, where Silurian rocks were found directly beneath Jurassic strata. Some lists of fossils are given, and the author recommends that further trials for Coal-measures should be made in the district south of Croydon.

XII.—Brief Notices.

1. Geology of Victoria and Tasmania.—Mr. Frederick Chapman has contributed Reports on the Middle Devonian fossils of the Buchan district and on the Silurian and Devonian fossils of the Mitta Mitta district, Victoria (Records Geol. Survey, Victoria, vol. iii, pt. ii, 1912). Among the Middle Devonian fossils of Buchan are *Favosites basaltica*, Goldf., var. *moonbiensis*, Eth. fil., *Conocardium*, *Murchisonia*, and *Cheirurus* (?). The age of the fossils of Mitta Mitta cannot be so definitely determined; some may be Silurian, others, including *Cyathophyllum* and *Favosites*, are probably Devonian. To the same publication Mr. Chapman supplies a note on the correlation, by means of plants, of the Tasmanian and Victorian Jurassic strata. He has also recently paid special attention to the Phyllocarida, which seem to occur fairly abundantly in the Ordovician Shales of the colony, and *Hymenocaris hepburnensis* is described as new. Some well-preserved specimens of *Haliserites dechenianus*, Goepp., have likewise been figured and described by Mr. Chapman, who in the same volume gives an illustrated description of the fossil scale of a *Ceratodus* from the Jurassic beds of Kirrak, South Gippsland, calling attention to the interesting point that this is the first occurrence of a fossil scale of the fish.

2. *Sphenophyllum* in Australia. — In a report on the Mount Mulligan Coal-field (Geol. Surv. Queensland, 1912, publ. 237, p. 11), Mr. Lionel C. Ball reports the discovery in the shales of Siberia Camp of the pteridophyte *Sphenophyllum speciosum* in association with *Glossopteris*. The single individual obtained is described and figured. Hitherto Australia has yielded only a single very imperfect specimen of *Sphenophyllum*, which came from the Lower Carboniferous beds of Port Stephens, N.S.W. The finding in Northern Queensland of *S. speciosum*, which is characteristic of the Lower Gondwana beds of India, is of great interest as affording another link in the chain of evidence connecting Australia, India, and South Africa in Permo-Carboniferous times, by way of the sunken continent Gondwana-land. Figures of *Glossopteris*, *Sphenophyllum*, and *Sphenopteris* are given in support of the age of the beds, as well as sections, maps, and illustrations.

3. Queensland, Department of Mines.—Among other interesting reports recently issued W. E. Cameron deals with the coals of North Ipswich and Dalby, gold at Ormeau, tin-lodes of the Charters Towers district, and olivines in the Toowoomba Basalts. These latter are of so fine a size and colour as to recommend themselves to European cutters for a market of 100 ounces per week. E. O. Marks deals with the *Glossopteris* flora near Hughenden and Pentland, coal near Chinchilla, and gold at Mount Emu Plains and Cape River.

4. Wyoming Geology.—An account by Mr. C. E. Jamison, of the Douglas Oil-field, Converse County, Wyoming, is contained in Bulletin 3, Series B, of the Report of the Wyoming State Geologist, 1912. The location of the fields, which are drained by tributaries of the Platte River, is discussed, and a sketch of the topography of the area is accompanied by a useful map. The geology is rather difficult, because Tertiary beds mask the Triassic, Jurassic, and Cretaceous rocks, and faulting causes further complications. Details of formations are arranged in a convenient table, and the various systems with their fossils are briefly discussed. A list of wells is accompanied by descriptive notes, and information under the heading "future development" is likely to be of value. The Muddy Creek Oil-field, in Carbon County, is similarly treated, and the bulletin is illustrated by eight plates.

5. Mining in Elko County, Nevada.—Mr. E. C. Schrader gives in Bulletin 497 of the United States Geological Survey a full account of the physical and geological characters of the important mining region which has in recent years been developed in Elko County, Nevada. It lies in an area of folded and tilted Palæozoic sedimentary rocks cut by granular intrusives and flooded by Tertiary lavas, principally rhyolite. At Jarbridge the mineral deposits occur chiefly as tabular, gold-bearing fissure veins and lodes in rhyolite, an interesting feature being the exceptional abundance of adularia. There appear to have been two distinct periods of mineralization, calcite and barytes being first formed and afterwards silicified by the rising of thermal solutions. At Contact and Elk Mountain the ore is mainly copper, but a little silver and gold are also present. The paper is well illustrated with maps and photographs, and is supplied with a good index.

6. Iron Ores of Tennessee.—Mr. R. P. Jarvis gives an account of "The Valley and Mountain Iron Ores of East Tennessee" (*Resources of Tennessee*, vol. ii, p. 326, 1912). Magnetite occurs in the Cranberry granite, and its occurrence is attributed to segregation from the gabbro dykes. Bedded deposits and pockets of brown and red hæmatite occur in association with Cambrian, Ordovician, and Silurian formations. The yield in 1910 of red hæmatite was 301,838 tons, and of brown hæmatite 430,409 tons.

7. Rhodesia.—From the Tenth Annual Report of the Rhodesia Museum for 1911 we learn that the rocks are arranged, the labelling of the mineral collection is getting towards completion, and that the palæontological series is to be displayed at an early date. Good collections of tinstone-bearing greisens and fine cassiterites are at present on loan.

8. Permian of Durham.—Dr. Woolacott's paper, printed in abstract only by the Geological Society of London in 1911, has now appeared in full in the Proc. Univ. Durham Phil. Soc., vol. iv (5), 1912. It runs to seventy pages, is well illustrated, and issued at half a crown, so should be useful to many geologists. Attention may be directed to several excellent photographs showing weathering of the local rocks.

9. The Hamada Country.—Under this title we welcome a short paper on a part of Sinai by G. W. Murray, the son of our late colleague, G. R. M. Murray, of the British Museum. The district contains the Sinaitic minerals, copper, turquoise, manganese, iron and petroleum, and a good series of Carboniferous rocks. It is also much broken by a series of titanic faults, one of which has a throw of 1,320 metres. The paper is illustrated by photographs and a well-printed coloured geological map. It appeared in the *Cairo Scientific Journal*, vol. vi (No. 74), pp. 264–73, November, 1912. The paper is frankly of a general nature, but contains many valuable geological notes.

10. Duddon Estuary.—Those interested in J. F. N. Green's paper on this area which was read before the Geological Society of London on March 27, 1912, and published by the Society in the Abstract of Proceedings, 1911–12, p. 71, will be glad to hear that the whole paper has now been privately printed by Mr. Green and is available for reading and consideration.

11. Microscopical Petrography.—Dr. F. E. Wright contributes to the *Journal of Geology* for September–October, 1912, a paper on microscopical petrography from the quantitative viewpoint, in which he emphasizes the fact, not always realized by petrographers, that the quality of the quantitative work is far more important than the quantity of the qualitative work, and reproduces the main features of his discussion and description of the most refined methods of microscopic research published by the Carnegie Institution of Washington.

REPORTS AND PROCEEDINGS.

I.—Mineralogical Society.

January 21, 1913.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

T. V. Barker and J. E. Marsh: Optical Activity and Enantiomorphism of Molecular and Crystal Structure. The general nature of enantiomorphous structures accompanying optical activity in the liquid and crystalline conditions was discussed, and it was pointed out that, since the optical activity observed in crystals of six substances, including epsomite and sodium chlorate, cannot be referred to the crystal structure, it must be due to an enantiomorphous configuration of the atoms within the molecule. Suitable enantiomorphous configurations have been deduced on chemical grounds, the constitution of the compounds being based on a modification of Werner's theory of co-ordination. The symmetry of the new spatial formulæ is in many cases identical with the symmetry, and, in particular, sodium nitrate can best be regarded as a racemate due to a mutual interpenetration of optical antipodes having spatial configurations similar to those suggested for the active forms of sodium chlorate, the symmetry of the double molecule being identical with that of a rhombohedron. The same type of molecular structure presumably exists in calcite and the rhombohedral form of sodium chlorate which crystallizes at high temperatures. It is concluded that many cases of dimorphism are of an analogous character, and, more generally, that polymorphous change is preceded by a re-arrangement of the atoms within the molecule.—H. Collingridge: Note on the Determination of the Optic Axial Angle of Crystals in Thin-section. In the case where one optic axis is visible in the field of view, the position of the second axis may be determined more conveniently than in the Becke and Wright methods from the optic axial plane and the extinction direction through the centre of the field.—Dr. G. F. H. Smith: Graphical Determinations of Angles and Indices in Zones. Two methods were described, which, unlike the moriogram, are not restricted to right-angled zones. In one a double tangent scale is placed on a pencil of lines spaced as in a gnomonic projection on a zonal plane in such a way that the 01 and 11 lines cross the scale at the given angles; the angles corresponding to any indices, or vice versa, are read off directly within the limits of the scale. In the second method a double diagram is employed, of which one half is a new form of the moriogram and the other is a representation of angles whose cotangent is the difference of the cotangents of the given angles; the method is general and unrestricted in its application.—Dr. J. Drugman: On the Goldschmidt Apparatus for Cutting Models of Crystals. The mechanism was described, and the method of using it explained.—Professor H. L. Bowman: On a Nodule of Iron Pyrites. The octahedral shape and the striations on the faces truncating the coigns of the tiny crystals point to their being pyrites, and not marcasite as usually stated.—A Chinese bowl carved out of an amethyst geode, and a set of scales and weights used by the native jewellers in India for weighing pearls, were exhibited by F. N. A. Fleischmann and E. Hopkins respectively.

II.—Geological Society of London.

January 22, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Fossil Flora of the Cleveland District of Yorkshire. I. The Flora of the Marske Quarry." By H. Hamshaw Thomas, M.A., F.G.S. With Notes on the Stratigraphy by the Rev. George John Lane, F.G.S.

In this paper the author describes several plants collected by the Rev. G. J. Lane and Mr. T. W. Saunders in the Cleveland district of

Yorkshire, which were sent to Cambridge for examination. Other specimens described were obtained by the author from the Marske Quarry and by the late Mr. Hawell, whose collection is now in the Dorman Memorial Museum, Middlesbrough.

The following species are dealt with: *Equisetites columnaris*, Brongn., *Sagenopteris phillipsi* (Brongn.), var. *major*, Sew., *Laccopteris polypodioides*, Brongn., *Dictyophyllum rugosum*, L. & H., *Stachypteris halleri*, a new type recently described by the author, *Coniopteris hymenophylloides*, Brongn., and *C. quinqueloba* (Phill.), *Todites williamsoni* (Brongn.), *Cladophlebis denticulata*, Brongn., a new species of *Marattiopsis* (a genus not hitherto recorded from Yorkshire), *Williamsonia spectabilis*, Nath. (microsporophylls of which were found by the author, throwing additional light on this type of flower), *W. whitbiensis*, Nath., and a female strobilus identified as *W.* sp., *Zamites* (*Williamsonia*) *gigas*, L. & H., *Psilophyllum* (*W.*) *pecten* (Phill.), *Tæniopteris vittata*, Brongn., *T. major*, L. & H., *T.* sp., *Wielandiella nilssoni* (Phill.), formerly known as *Anomozamites nilssoni*, *Otozamites feistmanteli*, Zigno, *O. graphicus* (Leck. *ex* Bean MS.), *Dictyozamites hawelli*, Sew., a Cycadean stem classified as *Wielandiella* sp., *Nilssonia mediana* (Leck. *ex* Bean MS.), *N. orientalis*, Heer, a new species of *Pseudoctenis* (a genus recently founded on specimens of Cycadean fronds from the Upper Jurassic of Sutherland), *Ginkgo digitata* (Brongn.), *Baiera longifolia* (Pomel), *Czekanowskia murrayana* (L. & H.), *Elatides setosa* (Phill.), and *Taxites zamioides* (Leck. *ex* Bean MS.).

The Marske flora, which includes several types not hitherto recorded from the Jurassic plant-beds of Yorkshire, is believed to be of Middle Jurassic age; specimens previously identified as *Zamites buchianus* (Ett.) and *Nilssonia schaumbergensis* (Dunk.), Wealden species, are described respectively as a new species of *Pseudoctensis* and *Nilssonia orientalis*, Heer.

A note is appended by the Rev. G. J. Lane on the stratigraphy of the Marske Quarry, situated on the northern face of the Upleatham outlier, about a mile distant from Marske-by-the-Sea. The Marske beds are assigned to the Lower Estuarine Series.

2. "The Derived Cephalopoda of the Holderness Drift." By Charles Thompson, B.Sc. (Communicated by G. W. Lamplugh, F.R.S., F.G.S.)

Although it has been known for a century that the Drift of Holderness is rich in derived fossils, for many years the collecting of them was neglected. However, in recent years collections of the Cephalopoda have been made, and it is now claimed that about 180 species of Ammonites are already in hand from the Glacial Drift. There are two important points about these specimens: the one, that a large number are new to Yorkshire lists hitherto published; the other, that the matrix of many of them cannot be matched now by our land exposures. It remains to consider whence they came.

The whole of the Lower Lias is so well represented by all its genera, and the rocky matrices are so characteristic, that it is urged that the ice plucked them from outcrops in the bed of a former North Sea; also that these outcrops show the continuity of the North Yorkshire Basin with that of North-Western Germany. The list appended to the paper supports this statement, for it shows that many gaps are now filled, which are obvious when Hyatt's lists for the two regions are compared.

The Middle and the Upper Lias afford much material, but the types are closer to those of North Yorkshire. The Oolites are very scantily represented, although the Lower Cretaceous is abundantly represented both by Ammonites and by Belemnites. Again, there is a great difference between the state of preservation of a collection made from the Drift and that of one which can be made now from the Speeton Clay in situ. Hence, the existence of a wide spread of these clays to the east is confirmed.

The Chalk Belemnites belong to a zone higher than any known in Yorkshire; therefore they probably came from the sea-bed.

CORRESPONDENCE.

FOSSIL BEADS (?) FROM THE GRAVEL OF BEDFORDSHIRE. ARE THEY EVIDENCE OF HUMAN WORKMANSHIP?

Sir,—As I was searching in a gravel-pit some few weeks ago one of the workmen brought me some very curious beads, which I enclose to you. They lay in various positions in the gravel, and were not all in one place, but scattered about in different parts of the pit, and they varied in size from that of a large marble to that of a pea. The supposition is that they are sponges, but possibly some of them may have been artificially fashioned and drilled for stringing. Advantage may have been taken in the case of the others of a natural perforation formed by the decay of the nucleus round which the sponge was formed, and the hole enlarged by one of those flint-borers which are often found, to admit of stringing on a sinew or a strip of hide. I am told that Palæolithic implements have been found in this pit, though I was not so fortunate as to find any. May I not pertinently ask, does not the occurrence of these beads point to a higher state of development in Palæolithic man than is generally conceded? Indications are not wanting which strongly support this view. Witness the cave-paintings of Altamira in Spain, and the occurrence of highly worked Palæolithic implements in caves of Aurignacian age in France, and lately of similar flints at Duston, Northants. While on this subject may I ask why there should not have been in Palæolithic times men of different stages of development living in different parts of the world as at the present day? The tendency has been to class all these ancient races as under the same degree and state of development. It is probably in southern regions where the earliest traces of the higher-developed Palæolithic man are to be found, climatic conditions in the north in those early times being less favourable to their development, if not precluding their existence altogether. I may say that the locality is Willington, Bedfordshire, and the formation river-gravel.

J. T. Banton.

Kingston Rectory, Cambridge.
January 18, 1913.

P.S.—The Rev. O. Fisher M.A., F.G.S., and Professor J. E. Marr, Sc.D., F.R.S., who have seen the beads, both support the view of their having been used as personal ornaments. They are often, though by no means always, perforated naturally. There is strong reason for supposing they have been used as beads.—J. T. B.

Note by the Editor on the so-called 'Fossil Beads'.

In reply to Mr. J. T. Banton's letter it may interest some of our readers to learn that the so-called fossil beads were figured by Dr. G. A. Mantell in his *Geology of Sussex* in 1822 from the Chalk near Brighton; and in 1829 by Professor J. Phillips in *Geology of Yorkshire*. In 1833 Samuel Woodward in his *Outlines of the Geology of Norfolk* figured several examples from Norwich and from Holt as *Millepora globularis* (now known as *Porosphæra globularis*, Phillips, sp., a small globular species of Calcisponge from the Chalk of England and the Continent). Their history is very extensive, and has been most carefully set forth by Dr. G. J. Hinde, F.R.S. (see Journ. Roy. Micro. Soc., 1904, pt. i, pp. 1–25, pls. i and ii), who describes and figures six species.

In Mr. James Wyatt's paper in the *Geologist* (vol. v, pp. 233–5, 1862) the writer says he first became acquainted with these objects about fifteen years earlier (1847) when uncovering some Anglo-Saxon remains in the Kempston gravel-pit, near Bedford, when several round stones perforated were met with; he adds, "so strongly was I impressed at the time that they were the personal ornaments of the ancient chieftain just exhumed that I actually presented them to the Archæological Society as Saxon beads . . . Subsequent examination of the Drift gravels convinced me that the balls were of an earlier period than the Anglo-Saxon, whether works of art or natural productions. They are described by naturalists as specimens of the Chalk fossil *Coscinopora globularis*, but the question is, how did they become perforated?" Mr. Wyatt, after having examined a great number of specimens, concludes the perforation in these small globular bodies to be *artificial*. In this opinion he was supported by Dr. Rigollot,[1] who wrote that "les petites boules avaient servi à former des colliers à l'usage des peuple sauvages"; but subsequently a strong objection was taken to this opinion by M. Albert Gaudry, who[2] denies that there is any evidence for the assertion that these are works of art, and asserts that they are found *in the Chalk* perforated in the same manner as those specimens found in the Drift.

[1] See account of Dr. Rigollot's observations (*Mémoire sur les instruments en silex*, etc., p. 16, Amiens, 1854). See also Lyell's *Antiquity of Man*, 4th ed., 1873, pp. 165–6, fig. 22.

[2] Trans. Inst. France.

In the same volume of the *Geologist* (pp. 235–6) Professor T. Rupert Jones points out that these bodies, so common in the gravel of Chalk districts, particularly in Bedfordshire and at St. Acheul, have all been, originally, derived from the Chalk in which they are *abundantly found*, either perforated or solid, or with a more or less shallow hole in their substance. They occur in the Chalk itself; on the beaches under Chalk cliffs (as at Ramsgate, etc.) and in drift beds, the materials of which have been furnished by the Chalk, and in the decomposed chalk along the bottom slopes of the North and South Downs.

"The concavity of the typical variety (*Porosphæra globularis*) becomes in many of the globular forms a small cavity, a hole, or even a neat cylindrical perforation. The roundness of the specimens and their holes and tubular cavities," says Professor Rupert Jones, "appear to have suggested to the old Flint-folk of the Valley of the Somme, that they might be used for beads; such perforated forms are frequent in the gravel that yields the flint axes. I may add" (he says) "that the imperforate forms occur in the gravels just as

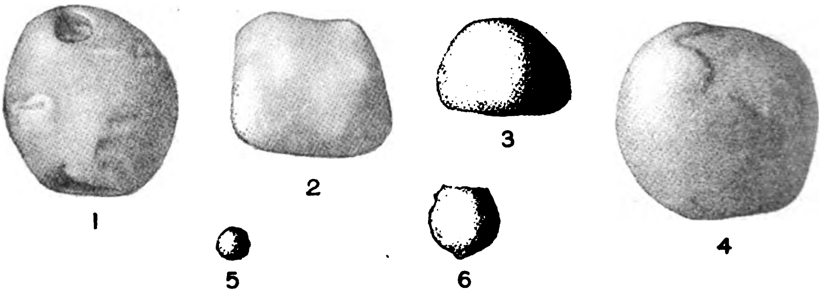


FIG. 1. *Porosphæra globularis*, Phillips, reproduced by the author's kind permission from pl. i of paper by Dr. G. J. Hinde, F.R.S. (Journ. Roy. Micro. Soc., 1904, p. 1–25).

much as the perforate. Also that the perforation of the non-drifted specimens in the Chalk is often just as smooth and straight as if artificial; the interior surface is *not worn*, however, but consists of the natural structure of the organism." (April 22, 1862.)

Dr. G. J. Hinde, F.R.S., in his valuable memoir on *Porosphæra* (Journ. Roy. Micro. Soc., 1904, pp. 1–25, pls. i and ii) says that Dr. A. W. Rowe, F.G.S., in his researches on the fossils from the different zones of the Chalk on the east and south coasts of England has met with many hundred examples of *Porosphæra* which he had placed in Dr. Hinde's hands for examination. This little sponge is common in the chalk cliffs of Yorkshire, Kent, Sussex, Isle of Wight, Dorset, and South Devon.

Dr. Hinde writes: "I may mention that within the limits of a moderately-sized garden situated on the slope of a chalk down at Croydon, Surrey, I have during the last sixteen years picked from the surface-soil 632 specimens of different forms of *Porosphæra* which have all been derived by slow weathering from the underlying Chalk."

Out of the large series of 2,902 specimens of *Porosphæra* examined and determined by Dr. Hinde, about two-thirds, he says, were obtained by Dr. A. W. Rowe, F.G.S., whose researches on the fossils of the different zones of the Chalk of England have become a classical work to all students of Cretaceous geology. In Dr. Hinde's opinion we find only 3 examples named *Porosphæra Woodwardi*, Carter, sp., from the Lower Chalk (Cenomanien) of Dover and the Dorset coast. 109 were obtained from localities in the Middle Chalk (Turonian), 99 of which are referred to *P. globularis*, 3 to *P. patelliformis*, and 7 to *P. arrecta*. But the majority of specimens, 2,770, were obtained from the Upper Chalk (Senonian), which yielded 2,244 examples of *P. globularis*, 257 of *P. nuciformis*, 149 referred to *P. pileolus*, 94 to *P. patelliformis*, 7 to *P. arrecta*, and 19 to "irregular forms of *Porosphæra*"; while of zones unknown, 14 are referred by Dr. Hinde to *P. globularis*, 1 to *P. pileolus*, 4 to *P. patelliformis*, and 1 an irregular form. In all, 2,902 were examined and determined by him, of which 2,357 are referred to *P. globularis* and 545 to the six other species. If we except the Lower Chalk, *P. globularis* occurs throughout the Middle and Upper Chalk, and is very abundant at Dover; in Devon, Seaford and Newhaven, Croydon, Margate, Brighton, Sewerby, and on the Dorset coast. These localities do

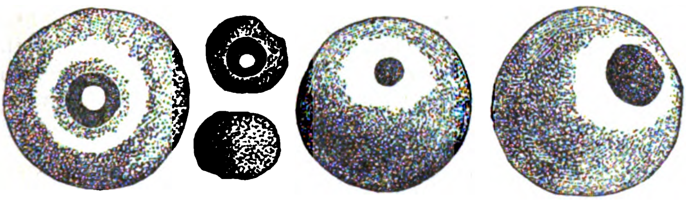


FIG. 2. *Porosphæra globularis*, Phillips, a small bead-like fossil sponge, derived from the Chalk, and found abundantly in the old river-valley gravels of Bedfordshire. The above figures are reproduced from an article by Mr. James Wyatt, F.G.S. (see the *Geologist*, vol. v, pp. 233–5, 1862).

not include the vast number met with in the Bedfordshire gravels and elsewhere *derived* from the Chalk, whilst it is abundant in the gravels at Amiens and Abbeville in France, and is present almost everywhere in the Chalk of Middle and Northern Europe. Dr. Hinde adds: "In form these sponges are generally rounded like peas or marbles, but are sometimes oval, loaf- or cushion-shaped, without any distinctive base; they are mostly free and unattached, but in many cases they grew round foreign bodies, which have been incapable of fossilisation, and these sponges now exhibit cylindrical hollow tubes which extend partly or entirely through them [see 1, Fig. 1]. Generally increase of growth is uniform over the surface, but in some instances fresh layers are formed so as only to cover portions of the surface at once [see 4, Fig. 1]. Small specimens are found of about 1 mm., the larger forms range to 34 mm. in diameter." (Op. cit., p. 19.)

In another place (p. 11) Dr. Hinde says: "Numerous specimens of *P. globularis*, and also of *P. nuciformis*, are penetrated by cylindrical tubes, some of which extend quite through, so that the specimen becomes a natural bead, whilst others reach only to the central portion of the fossil or beyond to near the opposite side, but without passing through it completely [see 1, Fig. 1]. The tubes generally pass straight through the centres of the rounded forms, but they are not definitely orientated in the cushion- or pear-shaped fossils through which they extend either longitudinally, transversely or obliquely. Out of 1799 specimens of *P. globularis* . . . 321 or about 18 per cent were perforated; 147 being completely perforated, or natural beads, whilst 174 were partially perforated. Of *P. nuciformis* there were tubes in 32, 6 of which extended through, whilst 26 only reached to varying depths in the fossils."

In a letter just received from Dr. Hinde, the writer says: "I do not doubt in the least that the perforations are *natural* and I think it is a mistake to suppose that they have been artificially produced. Numbers of specimens from the surface soil of my garden still have the holes solidly infilled with chalk and I have had to pick out the material with a needle, so that in these examples, at least, the holes were present when the fossil was imbedded in the chalk ooze of the sea-bottom."

He adds: "Mr. G. Crick gave me, some years ago, numerous specimens of *P. globularis* from the Bedfordshire gravels, in which they are so common as to serve as playthings for children! These gravel-specimens have their holes wider and larger as a rule than those obtained direct from the Chalk"—having been *waterworn*. "I quite agree with you that there is no definite evidence that they were used as beads by prehistoric man, although they might have been so used."

Referring to the abundance, origin, and wide distribution of this little sponge in the river-valley gravels of the Ouse, Mr. Horace B. Woodward, F.R.S., writes me: "The *Porosphæra* may well have come from the Chalk of Bedfordshire, which rises up in the Dunstable and Luton Downs—a continuation of the Chiltern Hills. It may also quite possibly have come indirectly by way of the 'Chalky Boulder-clay', which covers large tracts of the Bedford Vale resting on Oxford Clay, bordering the Valley Gravels. The gravel is largely made up of chalk-flints, but it also contains a good deal of Oolitic limestone, derived from the Great Oolite, etc., or from the Boulder-clay."

From the foregoing observations I think we may conclude—

1. That the cylindrical perforations, so commonly present in specimens of *Porosphæra*, *are natural*, *not artificial*, being met with as frequently in specimens obtained directly from the Chalk as in those met with in the Valley Gravel.

2. That their great abundance, scattered promiscuously through the gravel of Bedfordshire and elsewhere, affords no evidence in favour of their having been adopted as ornaments by prehistoric man.

3. That there is no case known or recorded in which they have been so used.

On the other hand, the shells of *Nassa neritea* and teeth of stag bored for suspension probably as a head-dress or necklace were found with the skeleton of a prehistoric man, probably of Neolithic age, in a cave at Mentone.[1]

There are some interesting notes by Dr. Robert Brown, F.L.S., F.R.G.S. (1868), and Mr. Alexander C. Anderson (Vancouver Island) on shells used by prehistoric people and modern North American Indians as ornaments (see *Reliquiæ Aquitanicæ*, by E. Lartet and H. Christy, edited by T. Rupert Jones, 1865–75, p. 296). In the same work also at p. 70 a shell-necklace from Cro-Magnon Cave is figured on B, pl. xi, composed of *Littorina littorea*, *Purpura lapillus*, *Turritella communis*, etc.

In the Cavern of Bruniquel explored by the Vicomte de Lastic in the Valley of the Aveyron *fossil shells* were found *perforated*, which had evidently been used as personal ornaments (see op. cit., p. 70); the collection is now preserved in the British Museum.

H. W.

SEA-WATER AND CRITICAL TEMPERATURES.

SIR,—How very true the parable of the moat and the beam is, and what a good example thereof is afforded by the letter of Mr. A. R. Hunt in your last number! He accuses his fellow-workers in geology, after a disquisition on the knowledge of foreign languages, of neglecting the researches of Daubrée and other workers abroad. Yet, although he has written on the subject of sea-water in volcanic and metamorphic action, he has apparently never read some dozen or more papers of mine on that subject, written years before (1892–4), though his own countryman.

I have distinctly shown that the critical point of water has nothing whatever to do with the question, and that we have to consider the physical conditions of the gas H_2O *in solution*, under varying pressure in fused silicates and oxides. I have urged the alkalinization of magmas by the assimilation of the alkaline salts in sea and other water, and accompanied by the liberation of the acid radicles in the form of the enormous emanations at volcanic vents. Furthermore, as mineralizers and fluxes, I have mentioned over and over again saline substances as being great agents in metamorphism. I laid down the fundamental principles of eruptive activity, which have never been controverted or controvertible because they are demonstrated and illustrated in all volcanic regions, principally by the nature and characters of the fragmentary ejecta of volcanoes.

Strangely enough, geologists and petrographers steadily and uniformly ignore the invaluable lessons taught by a study of fragmentary ejecta, while they cover thousands of pages with hypothetical, chemical groupings of massive rocks, ornamented by the most astoundingly complicated nomenclature, which, in the end, adds naught to our knowledge. Almost equally uselessly, they make elaborate calculations of percentages of different hypothetical felspars, and are blind to other structures that really record the vicissitudes between the primitive, purely vitreous paste and the consolidated rock.

[1] See *Comptes Rendus*, No. 26, p. 1597, June, 1872; also GEOL. MAG., Vol. IX, pp. 272–4, 1872 (with a figure); also op. cit., p. 368, and article by Professor John Morris, *Pop. Sci. Review*, July, 1872.

If Mr. A. R. Hunt will read my papers, he will find that a very full use is made of the experimental geology of foreign workers, where they explain the genesis of minerals or rock structure in igneous and metamorphic rocks.

I rather fear that the experiment of the piece of granite, suggested by Mr. Hunt, is not a fair reproduction of natural conditions. We must not expect the packing of any rock at great depths to allow fissures. The flow of solids under such conditions of high pressure and high temperature will reduce *all rock substances* to some advanced degree of viscosity, and allow the 'écoulement des solides', which, even in superficial rocks such as are found in mines, is known as 'creep'. The transmission of water to igneous foci is really a process of hydration and solution (and not percolation), too long to discuss in this letter.

I shall be pleased to supply Mr. Hunt with a list of my papers to which he may refer.

H. J. Johnston-Lavis.

Beaulieu-sur-Mer.
February 12, 1913.

MISCELLANEOUS.

Antarctic Expedition.

In Memoriam.

It is with deep regret that we briefly record the deaths from exposure and starvation, after accomplishing their mission to reach the South Pole, of the heroic five, Captain Robert Falcon Scott, Captain L. E. G. Oates, Dr. E. A. Wilson, Lieut. H. R. Bowers, and Petty Officer Edgar Evans. They had arrived within eleven miles of their stores, but a blizzard which lasted nine days and nights overwhelmed them. It is but poor comfort to know that the relief party found and buried the unfortunate explorers and recovered all their records and geological specimens.

Croydon's 'Woe Waters'.—Croydon's mysterious 'woe waters', the Bourne flow, made its appearance yesterday in Caterham Valley. In a few weeks the tiny stream on Welford's Farm, Whyteleafe, will have become a rushing brook, overflowing its banks for miles down the valley to Purley. Originally each visitation was regarded as foretelling war, plague, or famine. Mr. Baldwin Latham, M. Inst. C. E., who has studied each flow since 1866, attributes it to the uprising of the ground-water (plane of saturation) in the Chalk, after periods of much rain. He fixed the flow this year for February 3.—In part from the *Daily Telegraph*, February 1, 1913.

Erratum.—In a review of a memoir on "The Sedimentary Deposition of Oil", by Dr. Murray Stuart, F.G.S., Professor of Geology in Presidency College, Madras, the author's name was by an oversight printed "Stewart" (see Geol. Mag., December, 1912, pp. 570–1, and in the Index, p. 583). Please correct to "Stuart". The Editor expresses his deep regret.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. IV.—APRIL, 1913.

ORIGINAL ARTICLES.

I.—On a new Cynodont from the Stormberg.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in the University College, London.

WHEN I visited the town of Burghersdorp, Cape Colony, with the aid of a grant from the Percy Sladen Trustees, I was given by Mr. Maasdorp, the district surveyor, some fossil bones which he had collected at a locality on the farm Witkop, District Albert. Subsequently, through the kindness of D. V. Kannemeyer, Esq., its owner, I had the opportunity of examining the spot and obtained remains of Theropodous Dermosaurs, showing, as was already perfectly clear from its stratigraphical relations, that the locality lay in the 'Red Beds' of the Stormberg Series far above the *Cynognathus* beds of Burghersdorp, which have yielded so many Cynodont remains.

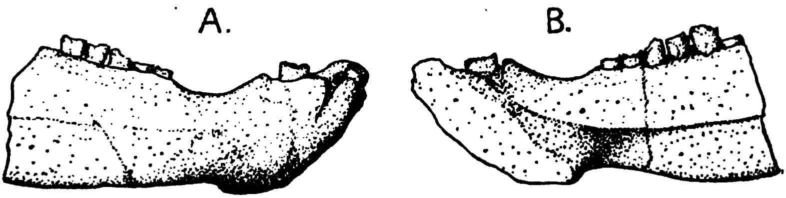


Fig. 1. Right ramus of the lower jaw of *Pachygenelus monus*, gen. et sp. nov. From the Red Beds, Stormberg Series, Witkop, District Albert, Cape Colony. Nat. size. A outer, B inner aspect.

The most important of Mr. Maasdorp's fossils was the anterior part of a small dentary belonging to an animal about as large as a fox terrier. This jaw seems to be certainly a 'Cynodont', and is the second specimen of that 'Order' found at so high a horizon. The specimen is represented in Fig. 1. Like all 'Cynodont' dentaries it is of a very mammalian appearance, the sole feature serving to distinguish it from the lower jaws of the latter group being the presence of a splenial, indicated by a step on the inner side which formerly received it. The symphysis is not fused, the symphysial face being well preserved and so placed as to show that the anterior part of the jaw was narrow, the two rami behind it separating more widely.

The interest of the specimen lies in its very unusual dentition. There are only two incisors, represented only by their roots. I_1 is a large tooth of oval section, which appears to be somewhat procumbent and lies close up to the symphysis. I_2 is a considerably smaller tooth, also of oval section, which lies close behind and outside I_1. The canine is a large tooth whose root, the only part preserved, is of oval section. It seems to have pointed directly upwards, and immediately follows I_2. Behind the canine is a long diastema, which is followed by a series of cheek teeth, six of which are preserved before the fracture which terminates the specimen. These teeth are small, single-rooted, and narrow from side to side; the root is deep and closely fits its alveolus. Only 3, 4, and 5 show anything of the crown, and even these are mutilated; they seem to be much alike, and a description of the last may serve for all. The crown is of an irregular oval shape, widest in front, where it is about three-quarters of its length. There are four cusps arranged longitudinally and forming the outer side of the tooth; the summits of the anterior three of these are broken, but it is certain that the first

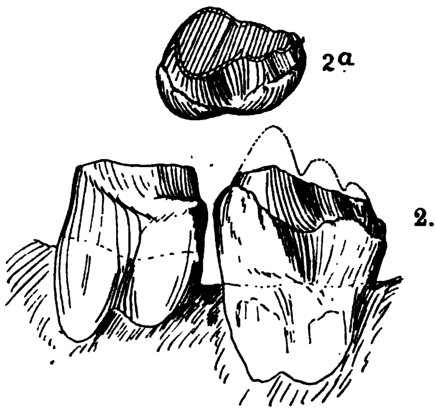


FIG. 2. The fourth and fifth molars of the right side of the lower jaw of *Pachygenelus monus*, gen. et sp. nov. × 8. Inner aspect.
,, 2*a*. The fifth molar viewed from above.

was much the largest and that they gradually declined in size and height to the fourth. On the inner side is a strong cingulum, whose position will be best understood from the figures. This shows a very faint crimping, as if in the descendants of our animal it might have developed cusps.

The systematic position of this specimen is difficult to determine; it is either a 'Cynodont' or a mammal. The occurrence of a splenial suggests reference to a former group, although it is exceedingly probable that a splenial did occur in the most primitive mammals.

The only known 'Cynodont' from the same horizon is *Tritherlodon riconi*, Broom, of which only upper molars are known; the type differs from ours fundamentally in the structure of the molars, which are transversely widened. All the other 'Cynodonts' differ in having more than two lower incisors, the Bauridæ offering the best comparison in that their incisors are large and somewhat procumbent.

They have, however, transversely widened molar teeth. ***Tribolodon*** differs in its much more slender jaw and scattered teeth. It is thus certain that our jaw, for which I propose the name ***Pachygenelus monus***, belongs not only to a new genus and species, but also probably to a new family of 'Cynodonts'.

It may be of interest to discuss briefly the derivation of the molar teeth of ***Diademodon***, not only for the intrinsic interest of the subject, but also for its bearing on the Tritubercular and allied theories of mammalian tooth development. As Broom has pointed out, the resemblance between ***Cynognathus*** and ***Diademodon*** is so close as to show that the two types with ***Trirachodon*** form a compact group of 'Cynodonts', and that it is very probable that the ***Trirachodon*** molar has been derived from a condition similar to that of ***Diademodon***, which in turn comes from a type like that of ***Cynognathus***. There is also no doubt that all three are descended from 'Therocephalian'

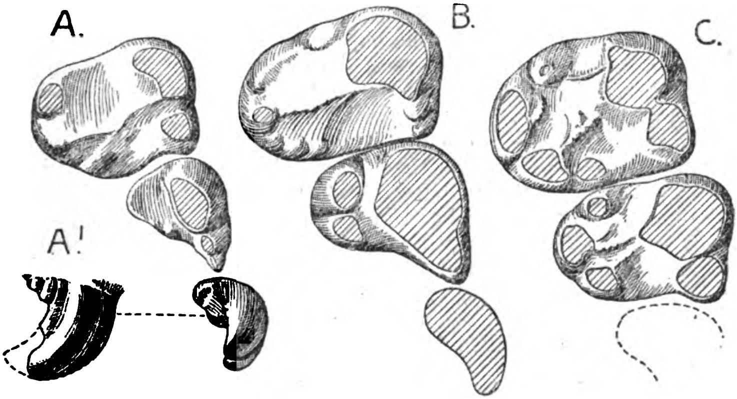


FIG. 3.

A. The three last molars of *Diademodon browni*. × 3.
A¹. The last molar of *D. browni*, external aspect. × 3.
B. The three last molars of *D. entomophonus*. × 3.
C. ,, ,, *D. mastacus*. × 3.

ancestors, having simple conical molars, of which those of the maxillæ bite outside the series in the lower jaw. In Theriodonts modification of such teeth apparently invariably begins by the addition of little cusps in front and behind the main primitive cusp: cf. ***Cynognathus***, ***Nythosaurus***, ***Galesaurus***, ***Tribolodon***. If we examine the last upper molar of ***Diademodon browni***, Seeley, we find a tooth consisting of a high backwardly curved cusp, whose anterior border is obscurely crenated; immediately behind this large cusp are two much smaller ones. On the inner side of the main cusp is a short, heavy cingulum, divided into two small cusps. This tooth practically only differs from that of ***Cynognathus*** in the presence of the cingulum. The next tooth in front has a similar main cusp, with two smaller posterior cusps. The cingulum is, however, much further developed, and the anterior of the two cusps which it bears is worn down, lying at the base of a vertically placed wear facet on the inner side of the main cusp. This tooth is obviously derived from a type similar to that behind it by the increase in size of the cingulum.

If we now turn to *Diademodon entomophonus*, Seeley, we find that the hind upper molar agrees in its section with the penultimate molar of *D. browni*; the crown is most unfortunately destroyed. The penultimate molar of *D. entomophonus* shows a further advance; there is still the large main cusp with a smaller posterior cusp, and the cingulum has grown considerably larger, but still supports the original two cusps on its inner side. If we compare this tooth with the corresponding tooth of *D. mastacus* we see a further change in the same direction; there is still the same main cusp with a smaller posterior cusp, but the cingulum is still further exaggerated and now has a small anterior in addition to the two original cusps. This tooth is identical in structure with the much worn antepenultimate molar of *D. browni* and is a typical *Diademodon* molar.

It must be clearly understood that these three species, which occur together, do not stand in any phylogenetic relation to one another, but the series seems to give a clear idea of the origin of the upper molars of *Diademodon*, the 'protocone' being the antero-external cusp and the whole of the inner part of the crown developed by the hypertrophy of the cingulum. If this is the case for the upper molars, it will also follow for the lower teeth, because the main cusp of the upper molar always bites outside the whole lower tooth, and if the lower molar had developed in the reverse way to the upper it would bite into an exaggerated external cingulum. It is remarkable that the view of the origin of the crown of the *Diademodon* molar put forward above agrees exactly in its general lines with the theory of mammalian molar development supported from embryological evidence by M. F. Woodward and from the analogy of the premolar development by many American palæontologists.

II.—Geological Notes on the "Land of Deep Corrosions".

By F. Kingdon Ward, B.A., F.R.G.S.

(PLATES V AND VI.)

A YEAR spent amongst the high mountain ranges of the Yunnan–Tibet frontier, where the Salween, Mekong, and Yangtze Rivers have been pinched together till they now flow parallel to one another for 200 miles in a belt of mountainous country averaging about 75 miles in width, enabled me, while prosecuting my botanical exploration, to ascertain a few facts of geological interest which form the subject of the present paper (see Plates V and VI and Figs. 1–4). The Tibetans of Kham, with more eye for the picturesque than one would have given them credit for, have, with amazing intuition, appreciated the subtle distinction between a land of high mountains and a land of deep valleys, and in their classical writings refer to Tibet under the name of *Nam-grog-chi*, which, according to Mr. J. H. Edgar, may be translated "the land of deep corrosions"; and this it undoubtedly is.

The Mekong-Yangtze Divide, looking south from the Chun-ma-la, showing screes and buttresses. Photograph taken at about 16,000 ft. elevation.

Before passing on to a description of the country it will be first necessary, for the sake of clearness, to say a few words about the distribution of rainfall and wind over this region, for while the main mountain ranges and valleys are clearly the result of crust movement, other minor topographical features are as clearly the direct result of local peculiarities in the distribution of these meteorological factors.

The prevailing wind is the south-west monsoon, which drenches the many parallel mountain ridges between Assam and China from

FIG. 1. The Yangtze in the arid region looking south, from near Batang, 3,000 miles from its mouth.

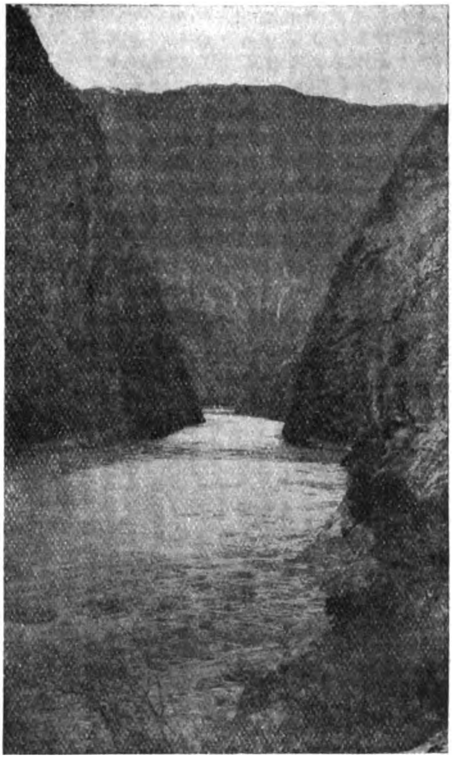


FIG. 2. The Salween River in the arid region, below La-kor-ah.

May to October. In about latitude 28°, however, the three main divides with which we are concerned receive such a considerable uplift that the westernmost acts as a partial rain-screen to the next, and so on. Thus there is, first, a high snowy range between the head-waters of the Irrawaddy and the Salween, a second between the Salween and the Mekong, and finally two isolated snow peaks between the Mekong and the Yangtze, all in about the same latitude.

This sudden uplift of the Salween–Irrawaddy divide is sufficient to check the high rainfall of the Salween valley, and consequently we here pass abruptly from a region of dense forest to a region of semi-desert; the Mekong–Salween divide is even higher, so that while gathering to itself whatever remains of the moisture in the air, and boasting an equally heavy rainfall, the Mekong valley or gorge beyond is, if possible, more desiccated than the Salween valley. But after crossing two high ranges the winds have now little moisture left, so that not only is the Yangtze valley arid but the Mekong–Yangtze divide also (Plate V); thus it stands in marked contrast to the other two rain-drenched ridges.

To return to the valleys. The combined effect of high wall-like mountains and lack of rain causes a local wind to blow in each valley throughout the summer as the heated air rises and cold air sweeps down from the snows immediately above to take its place, and since

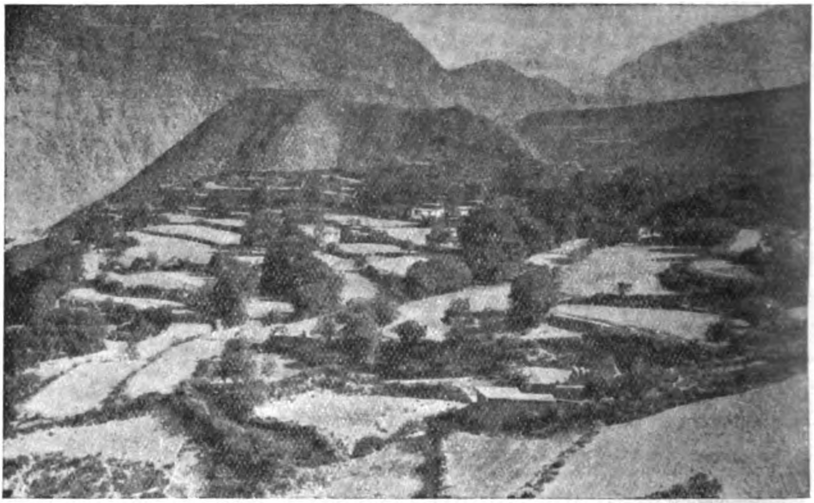


FIG. 3. An oasis in the arid region, Mekong River Valley, north of Yangtze.

the gorges get narrower towards the north the partial vacuum is more complete in this direction, and consequently the wind almost invariably blows from south to north up the valleys. It begins about ten o'clock in the morning, reaching its maximum intensity towards evening, and dies away about midnight or rather earlier. Meanwhile the rainfall has been reduced to a few inches a year, and from a distance the valley has the appearance of a desert, except where an alluvial cone, by permitting a little terracing and irrigation, forms an oasis (Fig. 3).

The most abrupt transition from luxuriant vegetation to semi-desert occurs on the Salween (Fig. 2), for the next two valleys are, to a certain extent, deprived of a copious rainfall even south of the snowy ranges, which we have called rain-screens; hence the transition, though obvious, is not so remarkable.

The Mekong River at Tew-kow, looking north, just before the arid region is reached ; the Mekong-Yangtze Divide seen in the distance.

An excellent illustration of the almost physical barrier which seems to be stretched across these valleys at the northern limit of rain is sometimes seen, the clouds, from which rain may be falling at the time, stopping short suddenly, and a ribbon of blue sky following the river northwards, though heavy masses of cloud still rest on the mountain-tops immediately above.

The phenomenon also illustrates the local character of the up-valley winds, for the clouds are entirely unaffected by it, gradually sailing over from the south-west under the influence of the prevailing wind.

In the Mekong valley just south of the arid region brilliant sun haloes are frequent in the summer, usually heralding rain; they are probably caused by clouds which have been blown across from the western range only partially disappearing during their passage over the hot valley, leaving a film through which the sun is seen. The

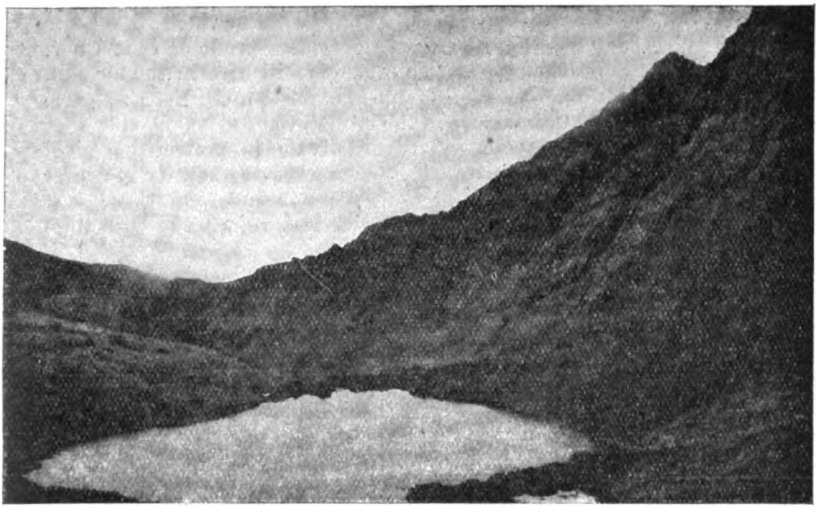


FIG. 4. Lake occupying a rock-basin at 16,000 feet on the Mekong–Yangtze Divide.

passage of clouds over the arid region on the other hand is often quite invisible, the rain drenching the western divide and later the eastern without affecting the intervening valley.

The effects of this abrupt change of climate in the Salween valley are various. In the first place the appearance of the valley changes from a typical U in cross section to a pronounced V, and at the same time the spurs change their direction from one of more or less parallelism to the main axis, to a direction more or less at right angles to it, thus forming as it were supporting buttresses.

Another change is to be noted in the tributary valleys which, in the arid region, exhibit to a very marked degree the 'reversed' type of structure, whereas in the more rainy regions to the south this structure, though sometimes apparent, is not nearly so conspicuous. [By a 'reversed' valley I mean a valley which begins in the mountains with a wide opening and gradually contracts as it descends, till finally it slits open the enclosing wall of the main river with a narrow gorge, the last thousand feet or so being over a series of high falls, or, more usually, down a long stairway.]

More interesting is a comparison of the Salween–Mekong divide with the Mekong–Yangtze divide (Plate V), the climatic difference being emphasized by the very different appearance of the peaks in the two cases, those on the Mekong–Salween divide being pyramids, showing clearly the curve of water-erosion, while the Mekong–Yangtze divide is crowned by towers and square-faced buttresses, splintered out by the action of such 'dry' denuding agents as rapid and extreme alterations of temperature, frost, wind, and so on.

The conservative action of the snow blanket on the Mekong–Salween divide must also be taken into consideration, for not only is the snow-line at least 3,000 feet higher on the Mekong–Yangtze divide, but the snow above 14,000 feet on the latter ridge disappears in the spring long before it does from the same altitude on the former, and similarly the Mekong–Yangtze divide is still bare in the autumn long after the Mekong–Salween divide is covered up. Yet these two divides are only 20 miles apart as the crow flies.

Hence, while the Mekong–Salween divide is protected against weathering, there is also available a much greater quantity of water for purposes of transport, so that we do not find here those vast screes which are such a characteristic feature of the Mekong–Yangtze ridge. (Plate V.)

Such differences of climate, of course, cause a marked difference in the vegetation of the two ridges which in turn has its effect on the rocks, partly conservative, partly destructive; but apart from the mere appearance so produced, this is not of great importance to us just now. It will suffice to say that while the rainy Mekong–Salween divide is richly carpeted with plants as high as the snow-line, the scree-clad Mekong–Yangtze divide presents an expanse of semi-desert for the last two thousand feet or so below the snow-line.

As regards the rocks exposed in this region, they may be broadly classed under three heads: (1) limestone, (2) a coarse-grained grey granite, and (3) various metamorphic rocks, though, so far as my experience goes, never with a schistose structure; but whereas similar rocks, limestone, granite, and metamorphic, are common to all three valleys, there is considerable divergence between the two great divides (each of which I crossed by three passes), the Mekong–Salween being capped by igneous rocks and the Mekong–Yangtze by limestone, which readily lends itself to splintering. The region is doubtless rich in minerals, and I have on one occasion climbed a mountain which seemed to consist almost entirely of some metalliferous ore.

We will now pass on to consider an important point in connexion with the Mekong-Yangtze divide, namely, the evidence for previous glaciation.

I have mentioned two snow mountains on this divide, one of which I saw very clearly, though I did not visit it; but the glaciers are certainly retreating, their bottle-nosed snouts being already some distance from the terminal moraines. Other evidence is derived from the 'hanging' valleys which descend immediately from the watershed and their peculiar 'tread and riser' structure, the valley floor ascending in a series of long abrupt steps to higher levels, each platform being the receptacle for a small lake occupying a rock-basin, one of which is shown in the photograph (Fig. 4, p. 151). Sometimes as many as five such lakes may occur in one valley, but usually there are fewer. Finally, we have the huge accumulations of angular rock fragments at the heads of the cirques, some of which at least are probably parts of old moraines. Of perched blocks and striæ, however, I saw no sign, though I do not attach much importance to that, for the climate is now all against their preservation.

Now it is evident that if the Mekong–Yangtze divide received as heavy a rainfall as does the Mekong–Salween divide there would be glaciers on the former where none now exist, so that the disappearance of the glaciers may be ascribed to a diminution of the rainfall. Why, then, has the rainfall become less? Evidently because it has been gradually cut off by the ranges to the west thrusting themselves up higher and higher till at last they form effective rain-screens. Nor is this all. Aneroid readings taken at different points in the beds of all three rivers show that the Yangtze flows at an average level of about a thousand feet above the Mekong, and the latter about the same height above the Salween, indicating a general western tilt of the country as it were, which within recent geological times has probably been in a condition of considerable instability; nor, indeed, are earthquakes rare, slight tremors being, I believe, frequent, which may help to account for the number of landslips, while hot springs issue from the base of every range. Such a tilt might easily cause a cracking of the crust, suggesting that these rivers really break through the rim of the Tibetan plateau along lines of weakness (fissures) or faults; but without believing for a moment that they have themselves carved out the deep gutters where they now flow, there is evidence, particularly in the Mekong gorges, for a very considerable amount of spade-work —for instance, pot-holes and ancient river cliffs now many feet above the highest flood-mark.

The crumpling and tilting of the rocks shows how the country has been pounded this way and that, but the general appearance points to a lateral pressure acting from the west (such as might be occasioned by a slight sliding motion of the main Himalayan axis eastwards), squeezing the belt of country up against an unyielding barrier in western China (supplied by the main east and west axis of uplift, separating the two great river systems of China), thus gradually raising the Mekong–Salween divide to its present considerable elevation, and so cutting off the rain supply of the older easternmost ridge—that remarkable freak of nature, the Mekong–Yangtze divide.

[The Editor is greatly indebted to the Syndics of the University Press, Cambridge, for permission to use the illustrations in this paper, which are reproduced from Mr. F. Kingdon Ward's forthcoming work entitled *The Land of the Blue Poppy: Travels of a Naturalist in Tibet.*]

III.—The Raised Beach of North Devon: its relation to others and to Palæolithic Man.

By Henry Dewey, F.G.S., H.M. Geological Survey.

WHILE mapping the Upper Devonian and Carboniferous Rocks in North Devon I took the opportunity of examining the raised beach of Barnstaple Bay and the deposits resting upon it. As a result of my observations I found that the sequence of these deposits is identical bed for bed with that of Cornwall, South Wales, and Southern Ireland, except that in place of the Boulder-clay there is in North Devon a bed of clay with striated stones which may not be of glacial origin. The position of the Boulder-clay over the ancient head, however, corresponds with the position of the bed of glaciated stones and indicates the infra-Glacial age of the 'head'. The fact that the 'head' is contemporaneous with 'Coombe Rock' has been held by all geologists familiar with the subject. It is a fact of first-class importance with regard to the relationship of man to the Glacial period, for it proves that man existed before these Boulder-clays were deposited. The evidence is inferential and supplied by the occurrence of Palæolithic implements of Le Moustier type in the Coombe Rock of Southern England and France. Granting, then, that the Le Moustier period is infra-Glacial, it remains to be seen to what Palæolithic period the raised beach belongs. We will proceed to consider the evidence available up to date, commencing with a brief account of the raised beach of North Devon.

North Devon.

From Morthoe to Westward Ho the raised beach can be recognized, intermittently notching the cliffs and forming a shelf some ten to fifteen feet above sea-level. It also extends inland as a flat terrace to Croyde village, and up the valley of the Taw towards Barnstaple. It has formed the subject of many contributions to geological literature, and a detailed account is therefore not required. A few localities will be selected where the sequence of deposits is well exposed, and short accounts of these will be given.

Between Croyde Sand and Saunton Down it is especially clear. In a road cutting and cliff sections in front of Down End House the sequence is readily recognized. The raised beach lies on a shelf and is covered by a variable thickness of current-bedded sand. Lying on this sand is a deposit of 'head' with a bed of large rounded stones resting on it, the top of this bed being 65 feet above O.D. The sands consist of alternate layers of hard and soft rock, the hard rock forming cornices with hollows beneath whence the soft sand has been eroded. The sand is shelly, containing numerous flakes and fragments and some whole tests of mollusca. Prestwich collected the following species[1]: *Helix virgata*, Da Costa, *H. cantiana*, Mont., *Bulimus ventricosus*, Drap., and quotes Gwyn Jeffreys, who remarks, "The *Bulimus* is a South European species, its most northern habitat being the south-west coast of France. The *Helices* are of species still living in the district." The fauna is warm temperate. The raised

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 284, 1892.

beach consists of pebbles of slate, hard sandstone, vein-quartz, quartzite, and chalk-flints. Among the beach stones the familiar boulder of red granite lies on the raised beach platform. It resembles a gneissose granite from near Cruinard Bay, Ross-shire; other boulders are found near by which appear to have travelled from the West of Scotland.[1]

If these boulders are from Scotland (and they are certainly not derived from the West of England) it is difficult to assign any agency other than ice as their transporters. If ice-borne the seas of Scotland were Arctic and those of Southern England cold.

We have, then, the following sequence of deposits corresponding with a sequence of climates—

Bed of rounded stones (?).
Head (?).
Cemented sand (warm temperate).
Raised beach, with boulders (cold).

The climatic conditions in which the bed of large stones was deposited is not indicated at this locality, but is suggested by a similar deposit near Fremington.

On the west side of Fremington Pill a low cliff is covered by beach stones and 'head', with a bed of clay and stones resting on top. Some of these stones bear deep scratches, are flat, with one side smooth and the other rough, while others are smooth both sides. The striæ are roughly parallel to one another, and each is an elongated wedge trenching the stone and ending abruptly at its widest part. The clay in which they rest is brownish and loamy. They closely resemble striated stones from glacial till, and had they occurred in a glaciated district would be accepted as of glacial origin. But as there is a doubt as to the age of the clay it may be objected that the striæ were produced by some agency other than ice. The evidence for their glacial origin is, however, as strong as that adduced for the glacial origin of the Palæozoic tills, which is generally, though not unanimously, accepted by geologists.

A bed of clay in the immediate neighbourhood of the section has long been worked for the 'Barum' ware. It is a fine, smooth, mottled clay and contains large boulders. One of them is a hypersthene andesite resembling the tholeite of Loch Craignish, Argyllshire, while another is a granophyre.[1] The clay was therefore deposited under such conditions as would permit large erratic boulders to be dropped in it. It may be Boulder-clay as Maw[2] thought possible, and if so supports the view of the glacial origin of the striated stones. The railway cutting a few yards north of the section described shows current-bedded sand resting on the raised beach and itself covered with 'head'. Hence the sequence in descending order is—

Bed of clay, with striated stones and boulders (? Arctic).
Head.
Cemented sand (warm temperate).
Raised beach (cold).

[1] Proc. Geol. Assoc., vol. xxi, p. 429, 1910.
[2] Quart. Journ. Geol. Soc., vol. xx, p. 445.

Cornwall and South Devon.

The striking resemblance between these beds and those of North Cornwall led me to re-examine a fine section at Trebetheric Point, opposite Padstow. At this locality a thick bed of boulders consisting of quartz, greenstone, elvan, quartzite, flint, and hard grit rests partly on 'head' and partly on, and in hollows in, the cemented sands. The sands contain marine fossils such as limpet, mussel, and crab. While the underlying beach is preserved in patches only, the raised beach platform is conspicuous in the adjoining bay and on both sides of the estuary of the River Camel. The sequence of deposits is identical with those in North Devon, and persists in some degree all round the coasts of Cornwall and South Devon. The raised beaches of the West of England were admirably described by Ussher and others, so that further description is not necessary. It should, though, be mentioned that Reid[1] discovered an important section of raised beach at 65 feet above O.D. This is in Penlee Quarry, near Mousehole, on the east of Land's End.

Mr. Barrow[2] also made an important discovery in the Isles of Scilly, where a bed of glacially striated stones overlies 'head' and raised beach. And, what is of even greater consequence, he correlated this glacial deposit with the 'Limon' or Loess of the coast of Brittany, pointing out the identity of the succession seen in Brittany and Cornwall. This is important in relation to the question of the age of the raised beach, for, as will presently be shown, the 'Loess' ranges from St. Acheul to Le Moustier in the Palæolithic Series. From the accounts given it is evident that the same sequence of deposition occurred along the coasts of the whole of Cornwall and Devon. Moreover, it includes deposits formed under varying climatic conditions ranging from cold, if not Arctic, at the commencement of the raised beach phase, through warm temperate, when the sands were deposited, to a second cold period whose incoming is marked by the 'head' and its maximum by the bed of striated stones. Such faunal evidence as we possess confirms this order of events.

Glamorgan and Southern Ireland.

We may next inquire how far this sequence extended into neighbouring regions, namely Glamorgan and Southern Ireland on the one hand and the south coast of England on the other. To take Glamorgan first, we know from the observations of Prestwich,[3] Falconer,[3] Tiddeman,[4] Strahan,[5] and Leach[6] that the deposits overlying the raised beach in Glamorganshire are in descending order—

Recent head.
Boulder-clay.
Ancient head.
Blown sand (often cemented into sand-rock), with breccia.
Raised beach, with erratics.

[1] *Geology of the Land's End* (Mem. Geol. Surv.), p. 75.
[2] *Geology of the Isles of Scilly* (Mem. Geol. Surv.), pp. 21–31.
[3] Quart. Journ. Geol. Soc., vol. xlviii, p. 263, 1892.
[4] Rep. Brit. Assoc., 1900, p. 760.
[5] *Geology of South Wales Coalfield* (Mem. Geol. Surv.), pt. viii, p. 127, 1907.
GEOL. MAG., 1911, p. 462.

If this succession be compared with that obtaining in Cornwall and Devon its close similarity is at once seen. In Glamorgan it is the more striking on account of the presence of true glacial till overlying the ancient 'head'. This till, therefore, represents the bed of striated stones and the boulder bed of Devon and Cornwall, and supplies strong evidence of the sequence of climates in Western Britain. The faunal evidence is entirely confirmatory. This is supplied for the most part from the mammalian deposits of the Gower Caves. In considering the relationship of these deposits to those of the contiguous raised beach Dr. Strahan[1] states of Falconer's conclusion that "granted his contention that the marine sands of the caves belong to the raised beach, and that the breccia associated with the marine sands corresponds to the breccia associated with the raised beach, it follows that the mammalian remains found in those deposits were placed there before the deposition of the boulder-clay".

The fauna described by Falconer is a mixed one, but contains mammalia indicative of a warm temperate climate. These are *Elephas antiquus*, *Rhinoceros leptorhinus*, *Hippopotamus major*, *Felis leo*, and others. Moreover, it is a fauna which is found in association with Palæolithic implements of the Chelles stage of culture. On the Continent the fauna associated with Chellean palæoliths is always a warm temperate or southern one; but in England northern animals are found with the southern ones. As we shall see later, the southern forms drop out of the fauna associated with a later stage of Palæolithic culture belonging to a period of advancing cold. In other words, the northern animals could survive a temperate climate, while the southern ones were either killed or forced to migrate on the approach of the cold.

It is important to assess the value of this evidence rightly so as not to overrate its significance. Taking Falconer's list of mammalia, the following significant species are referred to their several periods in the vertical columns:—

Gower Caves.	Pliocene.	Pleistocene.		
		—	Chelles.	Le Moustier.
Ursus spelæus	×	×		
Mustela putorius (Polecat)	—	×		
Lutra vulgaris (Otter)	×	×		
Hyæna crocuta	×	×		
Rhinoceros leptorhinus	×	×	×	—
Rh. tichorhinus	?	×	×	×
Elephas antiquus	×	×	×	—
E. primigenius	?	×	×	×
Sus scrofa	×	×	×	×

From the list[2] it will be seen that the fauna agrees more with the Chelles period than with either the Pliocene or Le Moustier. Prestwich

[1] *Geology of South Wales Coalfield* (Mem. Geol. Surv.), pt. viii, p. 127, 1907.
[2] E. T. Newton, in *Vertebrata of the Pliocene Deposits* (Mem. Geol. Surv., 1891).

compared the deposits in which these remains were found with the cemented sands overlying the raised beach south of the Bristol Channel, and concluded that they were synchronous, and that the animals of the caves formed an assemblage which was "the last one of the Pleistocene fauna with the exception of that of the Rubble Drift[1] or head". Hence the sequence in Glamorgan in relation to Palæolithic man is as follows:—

Recent head.
Boulder-clay (glacial).
Ancient head (Le Moustier and advancing cold).
Cave sands, etc. (Chelles, warm temperate).
Raised beach (cold).

In the South of Ireland Wright & Muff (Maufe)[2] recognized the same sequence at many localities, but two Boulder-clays overlie the head in superposition. The succession is therefore continuous from Eastern Devon to the south-west of Ireland. If we compare it with the one recognized on the coasts of Southern England we find it persists as far east as Folkestone. We may note in reference to climatic conditions that a fauna was found in the 'ancient head' of Cawsand Bay near Plymouth, which includes *Elephas primigenius* and *Hyæna*, while in a fissure near Plymouth these two forms were associated with *Rhinoceros tichorhinus*, *Rh. megarhinus*, *Cervus tarandus*, and *Bos primigenius*—forms which are characteristic of the 'head' further east.

Southern England.

The raised beach deposits of the South of England have long attracted attention, and have formed the subject of many contributions to geological literature. The chief observers are Mantell, Godwin-Austen, Prestwich, and Reid. In most cases where the beach is preserved the sequence is curtailed, but instances are not wanting where the several stages are recognizable. Thus we have—

3. Coombe Rock or head.
2. Clay or sands (temperate).
1. Raised beach.

3. All observers agree in regarding the Coombe Rock and head as being equivalent to one another, and there is no valid evidence to the contrary. The Coombe Rock has a tolerably rich fauna and one indicative of a cold climate. Moreover, it possesses a type of palæolithic implement by which its place in the Palæolithic sequence can be identified. I refer to the well-known Le Moustier type. These have been found abundantly in Coombe Rock at several localities, and at two overlying raised beach, namely at Sangatte near Calais and at Portslade near Brighton, where the rock included a palæolith approaching the St. Acheul type. The associated fauna includes *Elephas primigenius*, *Hippopotamus*, *Rhinoceros tichorhinus*, *Cervus tarandus*, *C. elaphus*, *Sus scrofa*, *Equus caballus*, *Bos*, *Hyæna*, etc. Reid and others have called attention to the glacial character of the

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 305, 1892.
[2] Sci. Proc. Roy. Dublin Soc., N.S., vol. x, pt. ii, No. 25, p. 250, 1904.

deposit, which received its name from Dr. Mantell, who first described its occurrence at Brighton.

2. Underlying Coombe Rock at Selsea Promontory is an interesting series of deposits described by Reid.[1] First is a floor with stranded erratic blocks, one deeply striated, and many of foreign origin, apparently associated with a bed of clay containing a fauna and flora of Arctic species, which in turn is covered by a loam with no Arctic but many warm temperate forms.

1. The raised beach platform is strewn over with boulders of rock that have travelled far from their source. These include granites, gneisses, porphyries, and many other varieties of igneous rocks which have been described by Prestwich, Bonney, and others. Prestwich considered that they were in part derived from Scandinavia, Central Germany, and the Ardennes, and had been carried by ice southwards and stranded on the shore of the South of England. He therefore inferred that the Straits of Dover were then in existence.

That this ice was not due to the advance of a glacial episode but rather to the retreat of one is evident from the fauna of the raised beach. Of this Prestwich says[2]: "Of the total of sixty-four species (of mollusca) only thirty-nine are common to the glacial drifts of the North of England and Wales. There is the absence also . . . of such northern shells as *Astarte borealis*, *Leda pernula*, *Fusus islandicus*, *Natica grœnlandia*, and others common in the glacial drift. The raised beach mollusca agree therefore pretty closely with the molluscan fauna now living in the British seas."

We are now in a position to compare the raised beach deposits and their faunas of the several coasts described previously, and to consider the sequence of events which led to their formation. To make the comparison readily intelligible the following tables are arranged:—

Climatic Conditions.	South of England.	Cornwall and Devon.	Glamorgan.	South Ireland.
Glacial . .	—	Bed of boulders and striated stones	Boulder-clay	Boulder-clay
Advancing cold	Coombe Rock	Head	Head	Head
Warm temperate	Beds of loam (in places)	Current-bedded sands—cemented	Current-bedded sand—cave deposits	Current-bedded sands
Waning cold	Glacial erratics Raised beach	Glacial erratics Raised beach	Glacial erratics Raised beach	Glacial erratics Raised beach
Glacial . .	—	—	—	—

From an examination of this table we may say that there can be no doubt as to the identity of the sequence over the whole of the southern parts of Great Britain and Ireland. Granting this, then, there remains to be considered the relation of Palæolithic man to the several episodes indicated by the deposits. The evidence given so

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 344, 1892. [2] Ibid., p. 263.

far is that a fauna closely related to that found with Chellean man occurs above the raised beach of Glamorganshire and below the 'head'. No Chellean palæoliths, however, have so far been found with this fauna, and so a doubt remains. But there can be no question as to its temperate character. The 'head' has yielded a fauna which is distinctive of Le Moustier times. Implements of Le Moustier type have been found in association with it in Coombe Rock both in England and France. The 'head' is therefore of Le Moustier period, in part at any rate, and this succeeds the supposed Chelles fauna of Gower.

Inland Localities.

We may now turn to the evidence supplied by deposits containing these palæoliths at inland localities. Perhaps no better district could be found where such Palæolithic deposits occur than the Thames Valley. We will, therefore, briefly consider the gravels of the Thames Valley in relation to Palæolithic man.

Since the Chalky Boulder-clay was deposited the Thames has eroded a wide channel during a succession of periods of activity alternating with long periods of rest. The result is a series of terraces at various heights above its present level. The highest of these has been termed the 100 foot terrace, and it rests upon Chalky Boulder-clay. The terrace is composed mainly of gravel containing an abundance of unworn Palæolithic implements of Chelles type, associated with remains of mammalia. Hence the Chellean period is later than the Chalky Boulder-clay. In making this statement reliance has not been placed upon the evidence derived from the Thames Valley alone, but also upon the known fact that wherever Chellean implements are found in an area of Chalky Boulder-clay they are always later than that deposit. The following instances will suffice to verify the statement. At Biddenham,[1] in Bedfordshire, the River Ouse has cut a valley 60 feet deep through Boulder-clay, and in its gravels palæoliths of Chelles type occur abundantly. In the classic localities of Suffolk[2] palæoliths of both Chelles and St. Acheul type occur in deposits overlying the Chalky Boulder-clay; while at Hoxne[3] the well-known section shows an infilled valley cut in Boulder-clay with St. Acheul implements in its upper gravels. The 100 foot terrace of the Thames is therefore Chellean and post-Chalky Boulder-clay. After its deposition uplift occurred with rejuvenescence of the river and its tributaries, which led to the formation of another terrace after the river had cut down its channel some 40 feet; this is the 50 foot terrace. Mr. A. M. Bell[4] has described from the gravels of this terrace at Wolvercote, in Oxfordshire, palæoliths of late St. Acheul or Le Moustier type. These are figured by Sollas[5] in *Science Progress*, and are associated with the

[1] J. Prestwich, Quart. Journ. Geol. Soc., vol. xvii, pp. 366–7, 1861.

[2] W. Allen Sturge, Proc. Prehist. Soc. E. Anglia, vol. i, pt. i, p. 43, 1912.

[3] C. Reid, "Relation of Palæolithic Man to the Glacial Epoch": Rep. Brit. Assoc., 1896, pp. 1–13.

[4] Quart. Journ. Geol. Soc., vol. lx, pp. 120–30, 1904.

[5] *Science Progress*, No. 15, 1910, p. 383.

'mammoth' fauna. Lower down stream, near Gravesend, a tributary has cut through the 100 foot-gravels of the main river a valley some 40 feet deep, which is partially infilled with Coombe Rock. In this deposit many thousands of palæoliths have been found. They are identical with the 'Levallois flakes' of French authors, and occur much as they were left by their manufacturers before the downrush of Coombe Rock overwhelmed them. The evidence derived, then, from the Thames Valley is that after the Chalky Boulder-clay had been deposited the Thames cut a deep valley in several stages. The highest of these contains (1) a fauna indicating a warm temperate climate, and (2) Chelles palæoliths. After a period of uplift another terrace was cut in which animals of a cold climate are found in association with Le Moustier palæoliths, St. Acheul man living in the interim. Expressed in a tabular form we have the following sequence:—

Le Moustier period = Coombe Rock } (advancing cold).
St. Acheul period }
Chelles period (temperate).
Chalky Boulder-clay (Arctic).

This sequence of climates is identical with that indicated by the raised beach deposits, but to make it clear the several stages are shown in the following table—

	Palæolithic Period.	River Thames.	Raised Beaches.
Arctic	—	Ponders End deposits	Boulder-clay
Advancing cold	Le Moustier	{ Combe Rock / 50 ft. terrace gravels }	Head
Warm temperate {	St. Acheul / Chelles / Strépy	100 ft. terrace gravels	Cemented sands and cave sands
Retreating cold	—	—	Erratics of raised beach
Arctic	—	Chalky Boulder-clay	—

Conclusions.

1. That the deposits overlying the raised beaches were accumulated during a period of variable climate, being Arctic at first, then ameliorating to warm temperate, and finally returning to Arctic.

2. During the inter-Arctic period early Palæolithic man lived. He is later than the Chalky Boulder-clay and raised beach and earlier than the Boulder-clay of Glamorgan and Southern Ireland.

3. These conclusions accord with those of Continental authors, a brief summary of which is appended.

Summary of Conclusions of Continental Observers.

Professor Commont[1] has worked out the relations of the valley deposits of the River Somme to the stages of culture of Palæolithic

[1] "Les Gisements paléolithiques d'Abbeville," Excursion de la Société géologique du Nord et de la Faculté des Sciences de Lille, à Abbeville, le 11 Juin, 1910; and "Comparaison des Limons Belges et Etrangers," Ann. Soc. géol. Belg., tom. xxxix, 1912.

Climatic Conditions.	Thames Valley.	Eastern England.	Southern and Western Britain, raised beach deposits.	Penck and Brückner.	Prof. Boule.	Prof. Commont, Somme Valley.	Dr. Obermaier.
Arctic .	Ponders End deposits	Purple Boulder-clay. 'Contorted Drift.'	Boulder-clay of Glamorgan and Boulder Beds of Cornwall and Devon.	Würm Moränen.	—	—	Le Moustier.
Advancing cold	Coombe Rock (Le Moustier), 50 ft. terrace gravels, uplift.	Brickearth of Mildenhall (Le Moustier).	Coombe Rock and Head (Le Moustier).	Niederterrassen Schotter, Jüngerer Loess (Le Moustier).	Late Loess (Le Moustier).	Late Loess (Le Moustier).	Late Loess, post third-glacial terrace of River Garonne.
Cold (?) .	St. Acheul.	St. Acheul of Warren Hill Gravels.	—	—	St. Acheul, post third-glacial.	St. Acheul Early Loess.	St. Acheul.
Warm temperate	100 ft. terrace gravels, Chelles, Strépy.	Chelles of Warren Hill Gravels.	Warm temperate fauna and flora in clays and sands.	—	—	30 metre terrace of Somme (Chelles).	—
Retreating cold	Uplift . .	—	Boulders on raised beach platform.	—	—	—	—
Arctic .	Chalky Boulder-clay, Plateau Gravels (Southern Drift).	Chalky Boulder-clay.	—	Riss Moränen.	—	—	—
Warm temperate	—	Interglacial Sands.	—	Hochterrassen Schotter, Älterer Loess (St. Acheul).	—	—	—
Arctic .	—	Contorted Till, Cromer, etc.	—	Mindel Moränen, Jüngerer Deckenschotter. Günz Moränen, Älterer Deckenschotter.	—	—	—

man. He finds that a terrace 30 metres above the bed of the river is covered with a sequence of gravels, sands, and the younger Loess which contain a fauna including *Elephas antiquus*, Hippopotamus, Horse, and the ancestor of *E. primigenius*. Along with these remains implements of Chelles type are found in abundance. Another terrace, 20 metres below this, is overlain by similar deposits, but the Palæolithic implements contained in these are later and include late Chelles (Chelléen évolué) and St. Acheul types. Both these terraces are covered with a younger Loess full of implements of Le Moustier type.

Penck & Brückner[1] consider that the younger Loess (Le Moustier) passes under the moraines of the fourth glacial episode. They thus agree with the conclusions of Professor Commont, but differ from him and from Professors Boule and Obermaier in placing the St. Acheul period in the second interglacial period. Professor Boule speaks of the discovery of St. Acheul palæoliths in the moraines of the third glacial episode; and Obermaier records them from the 55 metres terrace of the River Garonne, which he correlates with moraines of the third glacial episode.

These conclusions are shown in the subjoined table, where they are compared with the evidence derived from a study of the Palæolithic and glacial deposits of the southern parts of Great Britain. A very close agreement is seen to obtain among the European deposits of different localities, associated with the remains of Palæolithic man: an agreement which strengthens the evidence as to the age of the raised beaches of Southern England and Wales.

IV.—The Division of the Upper Chalk.

By A. J. Jukes-Browne, F.R.S., F.G.S.

THE Geological Magazine for February contained a lengthy criticism by Mr. R. M. Brydone of my article on the Recognition of Two Stages in the Upper Chalk, in the volume for last year. It is certainly curious that he should set himself the task of adverse criticism in such a voluminous fashion when he acknowledges at the outset that he sympathizes with my proposal. It appears, however, that he is dissatisfied with my reference to his work, and that he doubts the reliability of my lists of fossils from the new zones of *Offaster pilula* and *Actinocamax quadratus*.

The first is a personal question, and the facts are these: While I was collecting information about the zones of the Upper Chalk in Germany and France, Mr. Brydone wrote to me (October 3, 1911) saying that he proposed to make a new zone in Hampshire and Sussex by separating the lower part of the old zone of *A. quadratus* under a new name, and retaining a restricted zone of *A. quadratus* for the upper part. He and Mr. Griffith had already divided the old zone into three subzones, and he proposed to unite the two lower subzones into a zone of *O. pilula*, asking if I approved the use of that fossil as an index in spite of its being very rare in the lowest beds.

[1] *Die Alpen im Eiszeitalter*, vol. i, p. 112, 1901–9.

I replied in the affirmative and pointed out that the establishment of such a zone would bring our zonal arrangement into better accord with that of Germany, where a zone of *Scaphites binodosus* (containing *A. granulatus*) had been recognized as separate from the overlying zone of *A. quadratus*.

I am surprised that Mr. Brydone should profess to have some doubt about my intention to endorse his proposal and to accept his establishment of a new zone of *O. pilula* in Hampshire. What else could I intend when I stated that in Table III "the separate records of the zones of *O. pilula* and *A. quadratus* are based on those given by Messrs. Griffith and Brydone", to whose publication I had previously referred?

I did not "quote" from Mr. Brydone's letters nor mention any of the particulars which they conveyed, for that would have been unfair and discourteous; yet he complains that I ignored "the new grounds on which the proposal was based". The new zone was simply the union of two previously defined subzones, and it sufficed for my purpose to record his intention. How can there possibly be anything unfair in that?

He also thinks it was "hardly fair" to have written that the line at the top of the zone of *O. pilula* "has not yet been accurately determined in England or France", when I was aware that he had determined it in Hampshire. I admit that my meaning would have been more accurately expressed if I had written that the line had not been determined anywhere in the North of France, nor anywhere in England except in Hants. I present my apologies to Mr. Brydone for appearing to ignore his delimitation of the two zones in Hampshire, but I think most readers must have seen that I was thinking of the large areas over which the line of separation had not been determined, and for which records of the distribution of species were not yet available.

This brings us to the root of all Mr. Brydone's subsequent criticisms, and that is the value of *A. granulatus* as a zonal guide. His first remark is that the zone of *O. pilula* does not appear as such in all my tables, and that *A. granulatus* is introduced as if it were an equally good index to the zone as *O. pilula*. He feels certain that I intended "to lay it down that the ranges of *A. granulatus* (upwards from the *Marsupites* zone) and of *A. quadratus* (below the *Bel. mucronata* zone) corresponded with the two divisions of the old zone of *A. quadratus*".

He is, however, mistaken; I did not intend to make such an assumption, for in Table III I indicated the occasional occurrence of *A. quadratus* in the zone of *O. pilula*, where *granulatus* is the prevalent species. What I did assume was that *A. granulatus* did not occur in the restricted zone of *A. quadratus*, and I have yet to learn that it does. Mr. Brydone is at great pains to point out his own mistakes, and to explain that his own record of *A. granulatus* in the Hampshire zone of *O. pilula* is not reliable, but he does not state that he has found *A. granulatus* in the restricted zone of *A. quadratus*, either in Hampshire or Sussex.

I compiled my tables from the most authentic records accessible at the time, and those were the lists published by Mr. Rowe and by

Mr. Brydone himself. It seems that *A. granulatus* is a rare fossil in Hants and Wilts, but that does not prevent it from being a useful guide elsewhere, and Mr. Rowe's experience, as stated in his successive studies of the cliff-sections, is that it always occurs in the lower half of the old '*quadratus* zone' and does not range to the top of that zone, where *quadratus* usually occurs. Does Mr. Brydone mean to deny this? if so, let him say so and prove it, but he has no right to find fault with me for compiling lists in accordance with what has hitherto been regarded as an established fact.

The only published record of *A. granulatus* in the highest part of the zone is that for which I am responsible, as mentioned by Mr. Brydone, viz. in a quarry at Bramford, near Ipswich, where *Belemnitella mucronata* was afterwards found. That determination was made in 1902 and I cannot remember what the specimen was like, but I should not now like to maintain that it was *granulatus* without a second examination of it. The quarry may possibly expose the junction of the zones of *A. quadratus* and *B. mucronata*.

We come next to the Yorkshire Chalk, and I am told that I had no right to assume that the Yorkshire cliffs do not include any chalk of the restricted zone of *A. quadratus*. I have undoubtedly assumed that all the chalk in these cliffs and most of that inland belongs to the equivalent of the new zone of *O. pilula*, but I did not do so solely because true *A. quadratus* had not been found in the Sewerby cliffs. I relied on the positive facts (1) that *A. granulatus* is abundant throughout the exposed portion of the zone, and (2) that the thickness exposed in the cliffs is only 177 feet, whereas the total thickness of the whole zone of *A. quadratus* (so-called) must be about 400 feet.

The only place where a true *A. quadratus* has been found is the White Hill Quarry, No. 27 of Mr. Rowe's list and map, situate north of Bridlington and about 200 feet above the sea. An inspection of the map above mentioned will show that if 177 feet of chalk come into the Sewerby cliffs there must be some 340 feet of chalk between the basal outcrop of the zone and White Hill Quarry. Further, as Mr. Brydone has himself pointed out, the mere presence of *A. quadratus* does not itself prove that the restricted zone of that fossil has been reached. Hence the White Hill pit may still be within the limits of the lower zone, and, as Mr. Stather informs me that *S. binodosus* is fairly common in this pit, such a position seems very probable, for in Germany *S. binodosus* is only found in the 'granulaten kalk', and not in the German zone of *A. quadratus*.

Relying, therefore, on the association of *A. granulatus* and *O. pilula*, as well as on the absence of *A. quadratus*, throughout the Sewerby, Bessingby, and Carnaby areas, I felt justified in regarding this Yorkshire zone of *A. granulatus* as the equivalent of the German zone of *S. binodosus* and of Mr. Brydone's zone of *O. pilula*. If there is really any difference between the Yorkshire and the Hampshire zones, it is not (as Mr. Brydone suggests) that some of his higher zone may come into the Yorkshire cliffs, but that the Yorkshire zone of *A. granulatus* represents a larger portion of the old zone of *A. quadratus* than his zone of *O. pilula* does in Hampshire.

With respect to Sussex I relied on the published records, according to which *O. pilula* is common at intervals throughout the 170 feet exposed in the cliffs between Seaford and Brighton, while *A. granulatus* occurs through at least the lower 150 feet, where no true *A. granulatus* had been found. Moreover, when Mr. Brydone wrote to me in October, 1911, he said that he had found there was in Hampshire a marked break in the middle of the ancient zone of *A. quadratus*, and that "so far as is known *A. quadratus* does not range below it in Hants or Sussex". Since then, however, he appears to have obtained fresh evidence, and has found in Sussex specimens which he "*expects* to prove that there also *A. quadratus* ranged down into the upper division of the zone of *O. pilula*".

When I compiled my tables I had no reason to suppose that the restricted zone of *A. quadratus* came into the Sussex cliffs, and consequently I entered both *Inoceramus pinniformis* and *I. tuberculatus* as referable to the zone of *O. pilula*. When Mr. Brydone has published his fresh investigation of the Sussex coast-section, and has described the exact position of his restricted zone of *A. quadratus* in it, the precise location of these *Inocerami* will be of importance. The greater part of this higher zone must certainly be above all the Brighton chalk, and can only be found in the more western part of Sussex.

While I resent criticism that seems to be of a captious nature I assure Mr. Brydone and other readers that I welcome any fresh information and any definite corrections of the records in the tables which I compiled. The delimitation of the two zones in question has not yet been accomplished through the South of England nor in the North of France, and consequently my tables are a first attempt to show the change of fauna that seems to occur at about this horizon. Without essaying such a tabulation it would have been impossible to compare the zonal distribution in England with that which has so far been recorded in France and Germany.

With regard to Belgium Mr. Brydone makes a statement which is inaccurate. He says I have tabulated *A. verus*, *A. quadratus*, and *B. mucronata* as having "absolutely distinct ranges in Belgium", and thinks it "dangerous to tabulate the ranges of *A. verus* and *B. mucronata* as separated by two whole zones". I have not done so, and if he will look again at Table II he will see that both *A. quadratus* and *B. mucronata* are entered in the fifth column (zone of *A. quadratus*). I did not include *A. verus* because de Grossouvre in 1902 had expressed a doubt of its actual occurrence in the Craie de Triviéres, which represents the zone of *A. quadratus*. Possibly I should have accepted M. Rutot's record in spite of de Grossouvre's doubt, but Mr. Brydone knows that *A. verus* is very
not occ found above the *Marsupites* zone, and in his recently published
learn that *y of the Chalk of Hants* he records one from the
own mistake ne of Hampshire, remarking that "it is believed to
the Hampshi t that horizon for England". On the other hand,
that he has fo he *B. mucronata* recorded from Triviéres can really be
either in Han a form or species which does not seem to have been
I compiled Belgium or France, but which is known to occur in the
the time, an e in England.

Finally, I would point out that the main object of my article is likely to be lost sight of in a controversy about the precise line of division between two zones and the inclusion of certain beds and certain fossils in the one or the other or both. I wish to concentrate attention on the main question, and on this we are happily all agreed, that it is desirable to divide the old zone of *A. quadratus* into two distinct zones, a lower and an upper. Future research must determine whether the two zones in the south are approximately coterminous with the two similar zones in the north or not, and whether the difference between the two faunas is as great in England as it seems to be in Germany.

REVIEWS.

I.—The Origin of the Himalayan Folding.

A MEMOIR recently published in India by Colonel S. G. Burrard, C.S.I., F.R.S.,[1] suggests an explanation of the Himalayan folds which geologists cannot afford to pass in silence, as his geodetic work points to conclusions that are at variance with the generally expressed view regarding the immediate cause of overthrusting in such folded ranges. The commonly accepted mental picture of the Himalayan folds depicts the strata as pushed over by great tangential thrusts from the north, the movement being resisted by the stable and ancient *Horst* forming the Indian Peninsula.

Colonel Burrard's results suggest that this view of the mechanism of Himalayan folding is inconsistent with the fact that, parallel to the general fold axis, along the southern foot of the range, and extending for about 15 miles outside the visible foot of the hills, there is a band which is characterized by an extraordinary deficiency in gravity. The observations so far made show that this band is especially sharp and abruptly marked on its northern margin, that is along the foot of the range, and that the deficiency in gravity gradually diminishes towards the south. The gravity values are those that might be expected if we had an empty fissure of about 6 miles deep, or a partially filled cavity of very much greater depth.

Colonel Burrard insists that the deficiency is altogether too great to be due to a simple synclinal depression filled with light alluvium, and he points out that, whatever be its nature, one cannot conceive of a band of low gravity being caused by the thrusting of a mass of rock against the peninsular *Horst*. He is thus forced to adopt a complete reversal of the accepted mechanical system of overthrust-folding, and to contemplate the existence of a deep-seated fissure opening out by a northerly creep of the sub-crust, while the overlying sedimentary carpet becomes puckered and wrinkled to accommodate itself to its shortened base. These wrinkles form the Himalayan ranges, the southerly-directed overthrust-faults and folds being due, not to a positive pushing over from the north of the superficial film of rock, but to a pulling back of the deep-seated support.

[1] *On the Origin of the Himalaya Mountains* (Professional Paper No. 12, 1912, Survey of India, Calcutta).

There is no doubt that the observed *facts* cannot be challenged; they are not limited to a small number of uncorrected observations, and are of the same order of magnitude outside the foot of the Eastern, the Central, and the Western Himalaya. The corrections made for the subterranean partial compensation of the Himalayan protuberance, and even for the assumed disturbing influences of the distant major features of geomorphology leave the relative local variations in gravity still pronounced and unexplained.

The results quoted by Colonel Burrard as *observed* deflections of the plumb-line have been obtained by deducting the geodetic values of latitude and longitude from the astronomical values, the geodetic values being computed by triangulation based on the Clark-Bessel spheroid.[1] The deflections that ought to be expected from topographical inequalities are based on the assumption that the superficial crust has an average specific gravity of 2·8, and that inequalities are not compensated by corresponding variations in density below the crust. The deflections mentioned as calculated on the assumption of complete compensation are based on the results published by J. F. Hayford,[2] who assumes the existence of general compensation for surface inequalities uniformly distributed to a depth of 113·7 kilometres.

A single example will be sufficient to illustrate the results obtained for traverses made from the Himalaya to the plains. Kurseong (26° 52′; 88° 18′)[3] in the Darjeeling district at an elevation of 4,428 feet, Siliguri (26° 42′; 88° 27′)[3] immediately at the foot of the range, standing 401 feet above the sea-level, and Jalpaiguri (26° 31′; 88° 47′)[3] 13 miles out on the plains at an elevation of only 280 feet, are not far from a meridional line. Between Kurseong and Siliguri the deflection of the plumb-line ought to change by 19″ if the mountains were not isostatically compensated at all, and the difference should be only 11″ if Hayford's hypothesis of perfect compensation were applicable, but the observed difference is as much as 28″. Similarly, between Siliguri and Jalpaiguri the difference should be 7″ according to calculations from uncompensated topography, and only 4″ according to Hayford's theory, while the observed difference is 17″. Thus, for the whole distance of 25 miles, between Kurseong in the Outer Himalaya and Jalpaiguri on the plains, the difference in deflection is 45″ instead of 26″, as it would be without mountain compensation, and 15″, as it should be according to Hayford's hypothesis.

As long as geologists were content to believe in a cooling and shrinking core, we had a satisfactory mental picture of a collapsing and wrinkling skin. But this explanation was found to overreach itself, the folds in the coat being so flagrantly generous that if flattened out the Earth would have a cover several sizes too large for itself. However, the old theory received adventitious aid from the

[1] S. G. Burrard, *Phil. Trans.*, A, vol. 205, p. 218, 1905.

[2] *The figure of the Earth and Isostasy from measurements in the United States*, Washington, 1909.

[3] As the greatest arc of North latitude in India is less than the smallest arc of East longitude, the values stated in the usual order cannot be confused.

supposition that the crust has received much igneous material from inside, has expanded by hydration, and has otherwise grown. But there still remained, as Dutton pointed out in framing his theory of isostasy, qualitative as well as quantitative difficulties: the superficial overthrusting of folded ranges was still not explained with perfect satisfaction.

A new suggestion of the kind now made by Colonel Burrard thus deserves more than casual comparison with the data; for there are, it seems to me, many geological and physical considerations that debatably seem to fall into line with this new theory. Among these reference might be made in this short communication to—

1. The numerous tension faults, which show a general east to west trend in the northern part of the Indian Peninsula, and have affected in succession the pre-Carboniferous Vindhyan strata and the Permo-Carboniferous Lower Gondwana beds, while newer fissures of the same kind became the channels through which the Deccan Trap was erupted at the end of the Mesozoic era (cf. Mem. Geol. Surv. Ind., vols. vi, pt. ii; xv; xxi, pt. iii; xxiv, pt. i; and xxxi, pt. i). The general trend of these tension faults is significantly parallel to that of Colonel Burrard's assumed 'rift' and associated earth-folds.

2. The welling-up of a great granitic core behind (that is, to the north) of the band of exceptionally low gravity, and on the southern edge of the geosyncline which was slowly fed with marine sediment during much of the Palæozoic and most of the Mesozoic era.

3. The possibility that, if there has been at all an appreciable cooling of the earth since the close of Mesozoic times, such cooling would result in the contraction and splitting of what Colonel Burrard calls the sub-crust, while there would be little or no appreciable reduction in the temperature and size of the great central core.

4. Such loss of heat would be most rapid in the geosynclinal belts on which our great fold-ranges have always risen. This suggestion substantially agrees with that made by Dr. J. Milne from the distribution of earthquakes (33rd Report, Seismological Committee, Brit. Assoc., 1912).

5. Mr. R. D. Oldham has shown that the megaseisms—earth-shaking quakes—probably originate at great depths, and are but accidentally and rarely connected with the visible superficial faults in the seismic regions (Quart. Journ. Geol. Soc., lxv, 1–20, 1909).

6. The symmetrical character of those geanticlines which show overthrusting in opposite directions, does not conveniently illustrate even the worn-out textbook idea of a superficial crust collapsing and crumpling on a shrinking core.

The 'rift' postulated by Colonel Burrard is altogether different in depth and character to the fore-deep of Professor Suess, who regards the peninsula as a stable block against which the Himalayan mass is being rolled; this would not account for a band of deficient gravity outside and beyond the visible hills.

Up to last year ideas regarding the production of rifts at great depths were inhibited by the conclusions of C. R. Van Hise and L. M. Hoskins regarding the comparatively shallow depths at which the strongest rocks become plastic under the superincumbent earth-pressure; but Professor F. D. Adams (Journ. Geol., 1912, pp. 97–118) has shown experimentally that empty cavities may exist in a rock like granite under pressure equivalent to depths of at least 11 miles, and that they may exist at still greater depths if filled with liquids. Colonel Burrard's assumption, therefore, does not appear to be impossible from this point of view.

In 1904 the Rev. O. Fisher[1] partially anticipated the results now obtained by the Survey of India by calculating the deflections of the plumb-line in North India which would follow from his theory of mountain compensation by a 'root' extending to a depth of about 29 miles. The variations now observed are, however, more violent than those expected by Mr. Fisher, for the northerly deflections of the plumb-line decrease to zero at a distance of about 15 instead of over 60 miles from the visible foot of the hills. It will be interesting now to obtain a comparison of the observed deflections with those calculated by Mr. Fisher, whose theory, however, does not otherwise march, like that now offered, in consonance with the growing belief in a solid earth.

Thomas H. Holland.

II.—Index to the Stratigraphy of North America. By Bailey Willis. Accompanied by a Geological Map of North America, dated 1911. 4to; pp. 894, with 19 text-illustrations. Washington: United States Geological Survey, Professional Paper 71, 1912.

THIS elaborate volume, although designed to explain the geological map which accompanies it, will be a permanent and invaluable work of reference on the North American formations. In turning over the pages we are reminded of a letter by Dr. F. A. Bather on "Stratigraphical Names", printed in the Geological Magazine for March, 1912, p. 141. Therein he calls attention to the number of names for formations and periods, remarking that his card-index to them extends to a thickness of more than two yards; and he comments on the inconvenience of the application of the same topographic names to formations of different ages in various countries. In the present work we find a Hastings Series of Pre-Cambrian age; and such names as Lebanon Limestone, Athens Shale, and Canaan Dolomite applied to Ordovician strata in America. In that country, where so many British and other European names have been given to towns and villages, it would be difficult to avoid the application of some of them to local sedimentary divisions; and we find among

[1] *Phil. Mag.*, January, 1904, p. 14. According to an anonymous review recently published in *Nature* of February 27 (p. 704), Col. Burrard is said to have overlooked this paper by Mr. Fisher. He, however, answered it in the same volume of the *Phil. Mag.* (p. 292); but the Editor of *Nature*, although he is aware that Col. Burrard is in India and cannot thus reply for some weeks, has refused to correct his statement on the grounds that the remark "applies with perfect correctness to the memoir reviewed". In other words, the reviewer is able to distinguish between the knowledge possessed by Col. Burrard and that possessed by the writer of Col. Burrard's memoir! The existence of this uncanny ability suggests a clue to the origin of the legend that the Editor of *Nature* sometimes appears to confuse himself with the Author of it.

other familiar names, those of Bedford Oolitic Limestone, Mansfield Sandstone, and Elgin Sandstone applied to Carboniferous strata in the United States. Nevertheless, where such formations are of minor or purely local interest the matter is not very serious. In the work before us perhaps the majority of local geological divisions have a distinctly American savour; such as the Cusseta Sand, the Cussewago Sandstone, Swearinger Slates, Sacramento formation, Perry Sandstone, Sillery formation, Great Smoky Conglomerate, and Birdseye Limestone, to say nothing of other and more familiar names derived appropriately from native American localities.

Turning now to the geological map, we find it to comprise four large sheets, on the scale of 1 : 5,000,000 or about 1 inch to 80 miles. It includes the north-western corner of South America and extends therefrom to the Bering Strait, the Parry Islands, and Greenland, with insets showing the Windward and the Aleutian Islands. Each map has its separate series of index-tablets, desirable because in some areas the systems have been mapped in more detail than in others where they are undifferentiated. Moreover, there are some differences in the classifications adopted by the Surveys of Canada, Mexico, and the United States, while the chronological limits of formations naturally vary. Printed on one sheet of the map there is a general series of colour tablets, which shows at a glance the scheme of classification, the larger groupings being Archeozoic, Proterozoic, Paleozoic, Mesozoic, and Cenozoic, together with Pre-Cambrian and Post-Cambrian Intrusive rocks, and Tertiary and later Effusive rocks. It should be remembered that Professor Lapworth used the term Proterozoic or Protozoic for Cambrian, Ordovician, and Silurian. In the work before us Proterozoic is applied to the Pre-Cambrian, or in other words to Algonkian, which includes Huronian and Keweenawan. It is eminently satisfactory to find the names for the geological systems in harmony with those in general use in Europe, such as Cambrian, Ordovician, Silurian, etc.

The immense advance in knowledge of the geology of North America during the past sixty or seventy years is manifest when we compare this new map with the area coloured in Lyell's "Geological Map of the United States, Canada, etc., compiled from the State Surveys of the United States and other sources", and published by John Murray in 1845. Very little of Canada and but a small region west of the Mississippi were then coloured geologically. The present map has been compiled in co-operation with the Geological Survey of Canada and the Geological Institute of Mexico, under the supervision of Mr. Willis and Mr. George W. Stose.

Intended for use as a wall-map, as well as for local reference, the colours have been carefully selected, and the guiding principles in their adoption are set forth in an interesting and instructive manner. The International scheme of colours was found unsuitable; in North America, for instance, few distinctive tablets are required for the Mesozoic divisions as compared with those of the newer and older formations. The main systems are depicted, sometimes locally divided as in the case of the Carboniferous into Mississippian and Pennsylvanian, sometimes united as in the cases of Eocene and

Oligocene, Cambrian and Lower Ordovician. It may be remarked that the general appearance of the map is excellent, and it owes much to the careful preparation and drawing of the geological lines by Mr. H. S. Selden, who has utilized the published maps and important contributions from many geologists, whose labours and assistance are fully and cordially acknowledged. The map is divided by parallels at intervals of 4° and by meridians at intervals of 6°, and the enclosed spaces are designated by letters and numbers. These index divisions are utilized throughout the text to denote areas described, so that reference to the map is greatly facilitated.

Further, a number of sketch-maps are given in the text to show the distribution of igneous rocks, of Pre-Cambrian, Silurian, Devonian, Upper and Lower Cretaceous, and other main divisions.

In the text, as remarked by Mr. Bailey Willis, "The material selected comprises discussions of stratigraphy, some citations of fossils, and some views on correlation. The aim has been to state stratigraphic facts as fully as the data available or the scope of the work permit and to include as much as space allows relating to faunas and correlation."

This is but a bald statement of contents. The work, in fact, is a compendium of North American geology, with a bibliography of the stratigraphy containing references to 953 published books and papers and a capital index. All formations and local divisions in all districts on the mainland and in islands from the Pre-Cambrian to the Pliocene are described so far as possible. The Quaternary deposits are not dealt with, but on the map there is one tablet for alluvium, lacustrine and desert-basin deposits, Glacial Drift (in small part only), and beach, dune, and marine deposits of the Atlantic and Gulf coasts; and these are shown only where the underlying formations are completely concealed.

III.—The Geology of Dartmoor. By Clement Reid, G. Barrow, R. L. Sherlock, D. A. MacAlister, H. Dewey, and C. N. Bromehead; with contributions by J. S. Flett and W. A. E. Ussher. 8vo; pp. vi, 102, with 2 plates and 17 text-illustrations. Printed for His Majesty's Stationery Office, 1912. Price 2*s.* 3*d.*

THE area described in this memoir includes the central and greater part of Dartmoor. Cranmere Pool, a peaty hollow, noted as being in the centre of the region from which the Dart and other rivers radiate. is on the northern margin of the map; Sheepstor and the famous Burrator reservoir for the water-supply of Plymouth, Ditsworthy Warren, and Buckfastleigh Moor occur along the southern margin of the map. This large tract of granite is full of interest from scenic, antiquarian, and geologic points of view. Apart from the tors, the many standing stones, hut circles, tumuli, and even the old stone tramway made for the conveyance of granite from Haytor Quarries, are objects that are well calculated to arouse the attention of visitors.

Although upland peat-mosses are said to occupy most of the land, above 1,600 feet, to the north-west of the Princetown and Moretonhampstead road, only the alluvial or 'basin-peats' are coloured on the map, the approximate limits of the upland or hill-peat being indicated by dotted lines, not easy to distinguish at a glance, so that a text-map of the peat-covered areas would have been useful.

Most of the granite is coarse-grained with large crystals of pale felspar, but some small areas of fine-grained granite, as well as a few felsite or elvan dykes, are distinguished by colour on the map. The bordering ground is occupied by the Middle Devonian Limestone of Ashburton, by Upper Devonian slates with thin limestones, and by Culm Measures.

These Carboniferous rocks are subdivided into—

Shale and Grit	Upper Culm (?).
Radiolarian Chert . . .	Lower Culm.
Shale, Limestone, and Grit	

The Culm Measures are regarded as "the equivalents of the lower part of the Millstone Grit, and perhaps of the upper part of the Carboniferous Limestone", and it is considered doubtful whether any of the strata in the district are later than the Millstone Grit. Here we may ask, "What about the Pendleside Series or Upper Limestone Shales?"[1]

In the picturesque region of Holne Chase, as pointed out by Mr. Barrow, the Devonian is found to overlie the Carboniferous, the junction being a plane of overthrust.

Volcanic outbursts took place both in Devonian and Carboniferous times, and in the former case the rocks described by Champernowne as schalsteins (Ashprington Series) overlie the Ashburton Limestone. Although mostly "sheared and altered into schalsteins", in some instances the rocks, as observed by Dr. Flett and Mr. Dewey, "are sufficiently well-preserved to show that they had originally the characteristic pillow-structure of spilites." Pillow-lava also occurs around Marytavy, in close association with the Radiolarian Chert of the Culm Measures. Intrusive sheets of diabase or allied rock are also described as occurring both in the Devonian and Carboniferous strata. Two small dykes of Mica Trap, probably of Permian age, are likewise noted.

Petrographical descriptions are given of the granite and of the aureole of thermometamorphism surrounding it. Much of the granite is disintegrated and decomposed at the surface, so that it can be dug to a considerable depth with pick and shovel. No china-clay, however, has been found in the area, although it occurs and is worked in the country to the south. It is considered that the "granite probably forms a gigantic laccolite or intruded lake of molten rock, of which the upper surface was no great height above the present surface of the moor". The discussion raised some twenty-five years ago by Mr. Ussher, and carried on by Mr. R. N. Worth, General McMahon, and Mr. A. R. Hunt, is not dealt with, but the Bibliography contains the titles of their papers. To these should have been added the address on "The Geology of Devon", by W. H. Hudleston (Trans. Devon. Assoc. for 1889, and Geol. Mag.,

[1] See Ussher, in *Geology in the Field*, Jubilee Vol. Geol. Assoc., 1910, p. 886.

1889, pp. 560–3). One other paper only do we miss from the Bibliography, and that is by D. Mackintosh, entitled "Railway Geology, No. 1, from Exeter to Newton-Bushell and Moreton-hampstead" (Geol. Mag., 1867, p. 390). He gave some account of the small 'rock-basins' of Dartmoor, as also did Ormerod in his paper of 1859, noted in the Bibliography. Their observations might have been mentioned in the text.

There is an interesting chapter on "Tertiary and Drift", in which is discussed the origin of the present physical features. These include the plateaus (or relics of them) at elevations of about 800 and 1,000 feet; and the ravines, such as that of Lydford. Attention is drawn to the ancient stream-tin deposits, and to the agents that may have been at work during the Glacial period, leading to snow-slope screes, etc. It is observed (p. 62) that "taken as a whole the Dartmoor peat is rapidly wasting away", but locally there are indications of active growth, and it would appear that in the tracts above 1,600 feet the conditions of mist and cloud would be favourable as noted (p. 1). Further, it is remarked that "The peat-mosses, just now of little economic importance, will be worked again as fuel becomes more expensive and the better methods now in use are applied". At the same time, when the question of water-supply is considered (p. 89), the value of the covering of peat in storing water is pointed out, and it is questioned "whether it is advisable to allow the peat to be removed, unless at the same time Dartmoor is planted with trees". Among the metalliferous deposits are ores of tin, copper, arsenic, lead, silver, manganese, zinc, and iron, but there are few mines in work at the present time. "Tin, or perhaps mixed tin and copper-ore, was probably worked in Devon and Cornwall as far back as the bronze age," and "The manufacture of pewter in the third century probably led to alluvial working for stream-tin on Dartmoor". Particulars and sections of various mines are given. Ochre and umber are obtained from open works at Ashburton.

From the foregoing remarks it will be evident how much there is of scientific and practical interest in this well-written and carefully edited memoir.

Geological Survey Memoir.

IV.—Records of London Wells. By G. Barrow and L. J. Wills. 8vo; pp. iv. 213, with 3 plates and 4 text-illustrations. Printed for His Majesty's Stationery Office, 1913. Price 4*s.* 6*d.*

THIS work is a highly important supplement to the information gathered during many years, chiefly by Mr. Whitaker, and printed in Geological Survey Memoirs and other publications. The general lowering of the water-level in the Chalk, on which the supplies from the London wells and borings almost wholly depend, was discussed so long ago as 1851 by Prestwich, and has been more or less a matter of concern ever since. As remarked by the Director in his Preface, recent observations show that "Not only is the fall greater than was anticipated, but it has been taking place at an increasing rate during the last ten years". The need, therefore, of a special inquiry, not only into the causes of the depletion, but also of the unequal distribution of water in the Chalk of the London district, has become urgent; and the various matters are now discussed in a philosophic spirit by Mr. Barrow in part i, the introduction to this memoir.

The volume is divided into three parts, and we may conveniently commence by a brief description of the contents of parts ii and iii, which constitute the bulk of the memoir. Part ii (pp. 34–90) is a Catalogue of Published London Wells, the object being to record their precise sites, and to give details of supply and other information that in many instances had not previously been published. The actual records of the strata are not repeated, but some additional particulars relating to them are here and there inserted. The 6 in. London County map of the Ordnance Survey in the first place has been utilized to record the positions of the wells. Each sheet of the map has been divided in 2 in. squares with letters and numbers, and these sheets are deposited in the Geological Survey Office for public reference. By a series of abbreviations the data relating to each well are concisely noted in the memoir. They indicate where the record was published, the site of the well as marked on the 6 in. sheet, the elevation of the ground, the depth of well (shaft) and boring, diameter of bore, position of Chalk surface above or below Ordnance Datum, water-level, and yield of water in gallons per hour.

Part iii is a descriptive account (rather than list) of wells, mostly new, but a few previously published. Of most interest geologically are the records of the deep borings at Beckton Gasworks, East Ham; Chiswick; Southall; and Willesden (two). All of these five borings after penetrating the Gault entered rocks in all probability of Devonian or Old Red Sandstone age, at depths respectively of 975, 1,120½, 1,135, 1,098, and 1,153 feet from the surface. At Southall the strata contained fish-remains of Old Red Sandstone age. Saline waters were encountered in these old rocks at East Ham and at Willesden (Stonebridge Park). A brief account of the Palæozoic floor is given in the Introduction (part i). Among the records of the wells and borings no mention is made of Blackheath Beds, but they may be represented in the strata passed through at East Greenwich Portland Cement Works and at Shirley (pp. 113 and 203).

Part i (pp. 1–33), the readable portion of the memoir, is an essay mainly on the water-bearing capacity of the Chalk in different parts of the London District; and Mr. Barrow takes the opportunity of describing the methods of constructing the old and new wells and the headings in the Chalk. He points out how the water in the lower sandy portion of the Woolwich and Reading Beds, as well as that in the Thanet Sands (where present), may be directly connected with that in the Chalk. He discusses the character of the water obtained directly from the Thanet Sands at considerable depths, a matter dealt with by Mr. Whitaker in his *Geology of London*, 1889 (vol. i, p. 513), and more recently by Dr. J. C. Thresh, whose views were adversely criticised in *The Surveyor* for July 26, 1912. There is no doubt that the Thanet Sand water is mainly derived from that which enters the Chalk outcrop, and that it has undergone chemical changes that render it softer; but it is highly questionable whether the sodium-salts which it contains are derived from the preservation of original sea-water. The amount of sodium chloride has, however, been found to decrease in certain localities where pumping has been in progress for some time, and Mr. Barrow suggests that a part of the replaced calcium has passed into the form of a calcium-salt in the interstitial matter of the rocks.

Exceedingly important are his remarks on the relation of the water-supply in the Chalk to the geological structure. Not only are the effects of heavy loads of Eocene strata adverse to fissures and free circulation of water in the Chalk, but it is important to consider the undulations and faults in that formation. Thus the passage of water through the Chalk, apart from fissures, is dependent on the water-level, and is influenced by the lithological nature of the Chalk, and still more by the pressure of the head of water towards the margins of the basin. The consideration of these matters is greatly helped by two colour-printed maps prepared by Mr. Wills. One shows the contours in the underground water-surface or water-table of the London District for 1911; and the other shows the contours in the Pre-Tertiary Chalk surface, or, in other words, the height above or depth below Ordnance Datum at which the Chalk occurs where overlain by Eocene strata. Small maps are also inserted, for comparison, to show the underground water-contours in the London Chalk in 1878, between 1890 and 1900, and in 1911. Mr. Barrow is thus able to discuss the areas of maximum and minimum water-supply, and the causes for the distribution and local depletion. Moreover, the question of the drawing in of impure water from the valley gravels, where they directly overlie Thanet Sand and Chalk, and possibly of water from the Thames in certain low-lying localities, is engaging serious attention, as noted some few years ago by Mr. Clayton Beadle.

The effects of pumping carried out towards the margin of the London Basin are to decrease the head of water that would otherwise press towards the centre of the basin; moreover, the underground circulation is affected by the light or heavy loaded Eocene areas, as well as by the character of the Chalk itself. Mr. Barrow regards it as urgently necessary to raise once more the water-level in the London Basin, and suggests that much might be done by means of dumb-wells on the outskirts of the London District. Needless to say, his essay is one that will repay attentive study by all interested in the subject of water-supply from the Chalk.

V.—Brief Notices.

1. Union of South Africa: Mines Department.—We have received the Annual Reports for 1911 of the Geological Survey of the province of Transvaal (pt. iii, 1912, price 7*s*. 6*d*.). This volume contains a useful map, scale 1 inch to 30 miles, showing the areas surveyed up to the end of 1911. It may be mentioned that the report of the Director, Mr. H. Kynaston, is printed in Dutch as well as in English. The field-reports include one on "The Lower Witwatersrand System on the Central Rand", by Dr. E. T. Mellor,

and therein he has been able to adopt a definite classification and nomenclature for the strata, which should be applicable to the whole of the Witwatersrand area. The Director contributes a report on "The Geology of a portion of the Rustenburgh District, lying north of the Pilandsberg", and Dr. W. A. Humphrey describes "The Geology of the Pilandsberg", a remarkable igneous complex which is considered to mark an important centre of eruption of the elæolite-syenite magma. In addition to the field-work in the Transvaal an area of 342 square miles was mapped in Natal near Vryheid by Dr. Humphrey, who contributes "Notes on a traverse through parts of the Vryheid District and Zululand". There is also a short "Report on the Coal Resources of South Africa". The maps, sections, and pictorial illustrations in this volume are well executed and instructive.

2. Cainozoic Mollusca from South Africa.—The importance of careful collecting has received further emphasis from the report of Mr. R. Bullen Newton on some Cainozoic shells from South Africa (Records of the Albany Museum, vol. ii, No. 5, February, 1913, pp. 315–52—not 251–88 as in author's copies—pls. xvii–xxiv). The author describes a number of marine mollusca from the Cainozoic deposits of South Africa which form part of the 'Alexandria Formation' of Professor Schwarz, and are attributed to a probable Mio-Pliocene horizon. Attention is drawn to the fact that this formation was originally considered as of Cretaceous age on account of the occurrence of *Melina* cf. *gaudichaudi* in the upper part of the Need's Camp Limestones near East London. This had previously been described as a Cretaceous shell by Mr. Henry Woods under the name of *Perna* sp. This form of *Melina*, however, is proved to exhibit affinities with a South American Miocene shell, while it occurs in other districts of South Africa where the Alexandria formation is exposed in association with forms of mollusca showing a late Tertiary facies. It is explained that the Need's Camp deposits, as first demonstrated by Dr. A. W. Rogers, consist of an upper and a lower series of limestones distant some two miles from each other. The upper or younger beds contain this Tertiary *Melina* cf. *gaudichaudi*, while the lower or older beds are characterized by Polyzoa, etc., of undoubted Cretaceous age.

The Bemrose collotypes from photographs by H. C. Herring, of the British Museum, are extremely good and deserve a word of praise. The combination of a good photograph and a good collotype leaves little to be desired in the illustration of fossil mollusca.—C. D. S.

3. Water-Supply Papers of the United States Geological Survey.—We have received Nos. 284, 289–91, 296, 298, and 304 of these papers, and they deal with the surface-waters of the St. Lawrence River, the Colorado, the Great Basin, and the Sacramento River Basin, also with the waters of the Pacific Coast in California. Two of the papers constitute a gazetteer of the surface-waters of California. Of more geological interest is the paper, No. 294, entitled "An Intensive Study of the Water Resources of a part of Owens Valley, California", by Mr. Charles H. Lee, 1912. This valley lies in East Central California, and receives its water-supply from precipitation

on the eastern slope of the Sierra Nevada. It is an enclosed basin, so lined by impervious rock-formations that its ground-waters have practically no subterranean outlet. The only outlets for the water are afforded by evaporation from water-surfaces and damp soil and transpiration from vegetation. The alluvial material which forms the "valley fill" varies in size from large boulders to fine clay; and in arrangement it is partly mixed and partly in layers of well-assorted gravel, sand, and clay. It includes materials of the outwash slope and of the valley floor, the underground supply of water being obtained by percolation from precipitation on the surface, from stream channels, and irrigation. The surface area of the valley fill is reckoned to be 230 square miles, and its depth in places approaches 2,000 feet. Allowing an average depth of 1,000 feet, and having regard to the porosity of the material, it is estimated that nearly eleven cubic miles of water are stored. It is, however, remarked that the amount to be derived for practical purposes could not exceed that of the natural loss or overflow.

4. Building and Ornamental Stones of Canada.—Parts i and ii of a Report on these subjects has been prepared by Dr. W. A. Parks and issued in one volume (Ottawa, 1912, pp. 376). The first part consists of a general introduction to the subject, dealing with the chemical, physical, and geological features of building-stones, and with the methods of quarrying, testing, and preparing stone for the market. The materials include granite and other igneous rocks, sandstones, limestones, and slates. Many illustrations of quarries and of machinery are given. The second part consists of a systematic description of the building and ornamental stones which occur in that part of Ontario lying south of the Ottawa and French Rivers. It is prefaced by an outline of the geology of Ontario. Full particulars are then given of the various building-stones and marbles, illustrated with views of edifices in which particular stones have been used, views of quarries, and maps. There are also a number of coloured plates of limestones, dolomites, and sundry marbles, including sodalite. This mineral, the blue variety of which is regarded as one of the most beautiful decorative stones in Canada, is practically confined to Ontario, inasmuch as it is not known to occur elsewhere in sufficient bulk to be of economic importance. It is found as segregations in a belt of nepheline syenite, and can be obtained in slabs up to 4 feet square. In composition, sodalite is a silicate of sodium and aluminium, in which some chlorine is present.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 5, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "On Two Deep Borings at Calvert Station (North Buckinghamshire), and on the Palæozoic Floor north of the Thames." By Arthur

Morley Davies, A.R.C.S., D.Sc., F.G.S., and John Pringle, H.M. Geological Survey.

The two borings are about 370 yards apart in a due east-and-west direction. The eastern boring gives the following section:—

Altitude of surface = about 290 O.D.	Thickness in ft.	in.
Soil	4	0
Oxford Clay—*Ornatum* zone	93	3
Non-sequence.		
Forest Marble	38	9
Non-sequence.		
Great Oolite	59	6
Non-sequence.		
Chipping Norton Limestones	7	6
Non-sequence.		
Lias — Domerian, *Algovianum* zone to Charmouthian, *Jamesoni* zone .	240	6
Unconformity.		
Lower Tremadoc—Shineton Shales . .	954	6
	1398	0

The Oxford Clay is represented by grey and blue clays, the lowest bed of which is a hard, tough, brownish clay full of broken shell-fragments; among the forms identified from it are *Cosmoceras sedgwicki* (Pratt) and *C. stutchburii?* (Pratt).

The Forest Marble consists mainly of grey and bluish-grey oolitic and earthy limestones, with grey, brown, and green clays at the base. An exceedingly bright bluish-green clay, 3 inches thick, is also present. The limestones are very fossiliferous, but the organisms are badly preserved.

The Great Oolite is represented by grey limestones and grey marly limestones, dark-grey sands, and clays. The highest member is correlated with the 'Cream Cheese' top of the Great Oolite in the Bicester cuttings. From the upper part of the section *Terebratula bathonica*, S. S. Buckman, was obtained; near the base there is a 2 foot band full of *Rhynchonella* and *Ostrea*. The section is compared with the Fritwell-Ardley section on the new railway from Ashendon to Aynho.

The Chipping Norton Limestones consist of a yellowish oolitic limestone and a grey sandy limestone, also markedly oolitic.

The Lias is represented by pale-grey shales with very little variation in character. Near the base is a limestone containing fragments of Palæozoic rocks and many fossils, of which the most abundant is *Zeilleria waterhousei* (Davidson), characteristic of the *Jamesoni* zone. This limestone also yielded a derived fragment of *Echioceras microdiscus* (Quenstedt), a *Raricostatum*-zone fossil.

In the western boring only, strata yielding inflammable gas were met with. Reasons are given for believing that these may have been Triassic. If not, they are probably Upper Palæozoic.

The Tremadocian shales resemble those of Shropshire; their dip varies from 40° to nearly 90°. They show interesting structures resulting from differential movement; at several horizons they yield well-preserved examples of *Clonograptus tenellus*, var. *callavei*

(Lapworth), and *Obolella* (?) aff. *salteri*, Holl. They are traversed by two sills of olivine-basalt. The uppermost 50 feet are stained red.

The following new reading of the Bletchley boring is proposed:—

	Feet.
Oxford Clay	192
Forest Marble	33
Lias (Charmouthian) . .	185

An attempt is made to express the depth of the Palæozoic floor by a contoured map, and its possible constitution and tectonic structure are discussed.

2. "On the Skeleton of *Ornithodesmus latidens*, an Ornithosaur from the Wealden Shales of Atherfield (Isle of Wight)." By Reginald Walter Hooley, F.G.S.

The bones were obtained from blocks recovered from the sea after being washed from a huge fall of the Wealden Shales. Portions of the skeleton missing in the Atherfield specimens are supplemented by bones in the British Museum (Natural History), No. R/176, upon which the late Professor H. G. Seeley founded the genus. There are remarkable peculiarities in the skull which isolate it from all known families, such as the presence of a sixth vacuity and a transposition of the jugal and quadratojugal in regard to the supra- and infra-temporal arcades. The jugal is excluded from the upper arch, and the jugal and quadratojugal from the lower, which is formed entirely by the quadrate. The orbits are placed far back in the skull, and the quadrate articulation is much in front of them. The occiput is concave. Teeth occur only at the extremity of the long muzzle; they are set close together, and those of the upper jaw interlock with those of the lower jaw. The notarium, the humerus, the decussation of the ulna by the radius, the sternum, and femur all show divergence from other types.

The wonderful preservation of the bones enables the mechanism of the skull, joints, and movements of the limbs to be described.

The paper deals with the morphology, and institutes comparisons with other types.

The evidence proves that it is necessary to form a new family, and that *Ornithodesmus* has descended from a sub-order which should include *Scaphognathus* and *Dimorphodon*. The author suggests the withdrawal of these two genera from the Rhamphorhynchidæ, and the formation of a new sub-order; and also that there are three entirely different phases of development shown in the skulls of the known Ornithosauria, which permit of their division into three sub-orders.

Measurements of the bones are given.

Annual General Meeting.

February 21, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The Reports of the Council and of the Library Committee were read. Of the 63 Fellows elected in 1912, 43 paid their admission fees before the end of that year, making, with 13 previously elected

Fellows, a total accession of 56 in the course of 1912. During the same period the losses by death, etc., amounted to 58 (6 more than in 1911), the actual decrease in the number of Fellows being, therefore, 2 (as compared with a decrease of 5 in 1911). The total number of Fellows on December 31, 1912, was 1,292.

The Balance-sheet for that year showed receipts to the amount of £3,417 15*s.* 9*d.* (excluding the balance of £475 11*s.* 10*d.* brought forward from 1911), and an expenditure of £3,252 5*s.* 6*d.*

Reports were communicated from the Director of the British Museum (Natural History) and from the Director of the Museum of Practical Geology, regarding the progress accomplished in the arrangement of the collections transferred to those Museums by the Society.

The List of Awards of the various Medals and Proceeds of Donation Funds in the gift of the Council was also read.

The Report of the Library Committee enumerated the extensive additions made during 1912 to the Society's Library, and alluded to the re-arrangement of the Library which is now in progress.

The Reports having been received, the President handed the Wollaston Medal, awarded to the Rev. Osmond Fisher, M.A., to Sir Archibald Geikie, K.C.B., Pres. R.S., for transmission to the recipient, addressing him as follows:—

Sir ARCHIBALD GEIKIE,—More than forty years ago, in my earliest struggles with the elements of geology, I received much kindly encouragement from my revered teacher and relative, Osmond Fisher. Twenty years later it was my pleasure to follow his footsteps, and to profit by the closest scrutiny of his work, in the Isle of Purbeck. It is now my privilege to request you to forward to him, in accordance with a unanimous vote, the highest award which it is in the power of the Council of the Geological Society of London to bestow—the Wollaston Medal.

I have referred especially to his work on the Purbeck Beds, because it is that with which I have the closest acquaintance. Written as long ago as 1856, his paper on that remarkable group of strata has formed the basis of all subsequent investigations; but no less masterly was his account of the Bracklesham Beds of the Isle of Wight Basin, which followed in 1862. The two together placed him at once in the ranks of those pioneer geologists who, self-trained in all branches of their science, laid the foundations of British stratigraphy.

It is probable, however, that the name of Osmond Fisher will dwell in the memory of posterity more especially as that of the author of the *Physics of the Earth's Crust.* First produced in 1881, that work was founded on geological reasoning and mathematical proof which it was within the power of few to appreciate. Its value, growing in recognition during the lapse of more than thirty years, is now acknowledged, and the book has taken rank as a classic on what is perhaps the most recondite subject which a geologist can be called on to investigate.

It is needless to refer in detail to the papers on a variety of other subjects with which Mr. Fisher has enriched geological literature, for they have already been mentioned from this chair on the occasion of the presentation to him of the Murchison Medal. But to what was then said I will now add that we are rejoiced to see him still maintaining his interest in current geological work at the great age of 95, and that it is a satisfaction to us to add this further proof of our appreciation of his labours.

Will you, therefore, be so good as to transmit this Wollaston Medal to Osmond Fisher as a recognition by the Council of the lasting value of his "researches concerning the mineral structure of the Earth".

Sir Archibald Geikie, in reply, said :—

Mr. President,—No duty at once more honourable and agreeable could be entrusted to a Fellow of this Society than to act as a deputy for one of the most venerable and esteemed of our colleagues and to receive on his behalf the Wollaston Medal, which has been awarded to him in recognition of the value and distinction of his contributions to geological science. I have been favoured with a short statement from Mr. Fisher, which I will now read :—

"It is indeed a most gratifying surprise to me that the Council of the Geological Society should have considered me worthy of their highest honour, the Wollaston Medal. At my great age (95) I shall not be able to attend and to offer my grateful thanks in person. I think that the Council must have formed a higher opinion of my merits than I have, but I must not quarrel with that. I once had as a pupil a scion of the Wollaston family. He was an entomologist, and wrote a learned work upon the insects of Madeira. He described the insect-remains which I found in Lexden brick-pit.

"I am thankful to say that I am still able to take an interest in our science. I am engaged at present in a mathematical investigation of the effect of an elevated plateau, like the Himalayan, when below the horizon of a station, in increasing gravity there. It will have to be taken account of in drawing conclusions from observations on gravity in the plains of India. My friend Davison is helping me with the arithmetic, in which I cannot trust myself. Arithmetic was not taught at Eton when I was there. I am afraid that the chief interest in my problem will be mathematical. In all problems of attraction hitherto the curvature of the earth's surface has been neglected. I have taken account of it, I believe, for the first time."

In receiving this Medal for transmission to our revered Associate, I should like to add an expression of my own indebtedness to the illuminating suggestiveness and clear presentation of his contributions to physical geology. It is astonishing and delightful to see him, at his advanced age, still full of mental alertness and enthusiasm, busy as ever in the continuation of the long series of mathematical investigations with which he has enriched geological literature. He has set to all of us a noble example of modest, earnest, and unwearied devotion to the cause of our favourite science. Let us trust that the brave veteran may not only live to complete the research on which he tells us that he is engaged, but prolong for years to come his sunny and beneficent old age.

The President then presented the Murchison Medal to Mr. George Barrow, F.G.S., addressing him in the following words :—

Mr. Barrow,—It is a great pleasure to me to hand to one who has been my colleague for many years a tribute paid by the Council of the Geological Society to a life spent in the furtherance of geological science.

In awarding to you the Murchison Medal they have borne in mind that you commenced your official career by investigations of a part of Yorkshire remarkable both for the development of Lower Mesozoic rocks and for its physical features, and by writing a terse and lucid account of it in the North Cleveland memoir. They remember, too, that after assisting in the mapping of the West Yorkshire dales, you proceeded to the Scottish Highlands, and that by there introducing modern petrographical methods you obtained results which have left a permanent mark in the literature on that fertile source of geological controversy. Your paper in 1893 on an Intrusion of Muscovite-Biotite Gneiss has taken high rank, not only as a storehouse of careful observations on the characters of igneous and metamorphic rocks, but as elucidating the problems connected with hypogene geology. It was followed by announcements of your discovery of chloritoid in Kincardineshire and of the possible occurrence of Silurian strata in Forfarshire; while in 1904 you threw much light on the difficult question of the relationship of the Moine Gneisses of Perthshire to the metamorphic rocks of other parts of Scotland.

On your transference to Devon and Cornwall the experience which you had gained was utilized in unravelling the structure of that tormented region, and in studying the phenomena presented by the metamorphic aureoles round the granitic intrusions. Here also your paper on the high-level platform of Bodmin Moor proved that more recent phenomena were not escaping your attention. At the present time the work upon which you are engaged in Warwickshire is already throwing much light on some obscure stratigraphy.

Will you allow me, as an old colleague who has had every opportunity of judging, to add my own testimony that your work, wherever you have been placed, has been characterized by that thoroughness and conscientiousness in the field which alone can lead to permanent advance in the interpretation of geological phenomena. On behalf of the Council I beg you to accept this Medal and Award.

Mr. Barrow, in reply, said:—

Mr. President,—I feel deeply the honour which the Society has conferred on me by the award of the Murchison Medal. I have spent many years working on those Highland rocks in which the founder of this Medal took so keen an interest. The Murchison Medal has now been awarded to several workers on these rocks, and as no two of us have come to the same conclusions, it is gratifying to feel that the Fellows of this Society can rely implicitly on the impartiality of its Council in its awards. I have to thank you very much for the kindly way in which you have spoken of my work; it is especially agreeable, as coming from an old colleague and the head of that branch of the service to which I belong, which makes it a special pleasure to receive the Medal from your hands.

In presenting the Lyell Medal to Mr. S. S. Buckman, F.G.S., the President addressed him as follows:—

Mr. Buckman,—The Lyell Medal is by custom associated more especially with palæontological research. It is, therefore, fittingly awarded to you in recognition of the conspicuous place which you hold among British palæontologists, as regards both your intimate knowledge of species and your philosophic treatment of your subject. While you are an eminent exponent of that school of thought and mode of study with which the name of Hyatt is associated, your own work exhibits a marked originality and independence of outlook. Moreover, not only is it pregnant with suggestive ideas, but it forms an example of pure scientific research having proved to be of value in practical application.

Your investigations on the generic relationships of the Jurassic Ammonites are the best example of your specialized labours. In a great monograph on the Ammonites of the Inferior Oolite Series, and in other works, you have sought to apply with precision the principles which underlie the correlations between ontogenetic and phylogenetic growth. Your research among the Brachiopods is no less illuminating as an example of the application of evolutionary principles; and, in dealing with the fossil forms, you have illustrated the production of similar morphic sequences in separate stocks and the frequency of homœomorphy.

The zonal method has been applied by you to stratigraphical problems with exceptional minuteness and accuracy. So great is your experience in handling difficult questions of zonal correlation that you have acquired powers of interpretation which seem almost instinctive.

From my own knowledge I can speak of the value of your services in revising collections in public museums, and in converting mere accumulations of fossils into orderly sequences, eminently instructive as regards both evolution of species and stratigraphical significance. It is my privilege to hand to you this Medal and Award in recognition of brilliant and original palæontological research.

Mr. Buckman, in reply, said:—

Mr. President,—It is with feelings of very great pleasure that I receive the unexpected honour of the Lyell Medal awarded to me by the Council; and when I listened to your kindly references to my work I felt that your recognition of its merits was far too flattering, especially when so much of what I hoped to accomplish still remains undone owing to certain causes. But it gives me particular pleasure to receive this award from your hands, for you belong to a body of scientific men whose practical work in geological surveying enables them to judge the value of stratigraphical labours.

It is now thirty-two years since the Society did me the honour to accept a paper from my pen. My later work has followed that paper up, though in more detail in the nomenclature both of strata and of species. But my later work is guided by my interest in the study of evolution, good illustrative subjects being found among Ammonites and Brachiopoda. This stratigraphic and classificatory work was and is the necessary, if somewhat monotonous, spade-work for evolution; for it was useless to compile genealogies while the sequence of strata was unknown in detail, and while nomenclature included polyphyletic forms under the same designation.

Through attention to and insistence on the importance of apparently trivial details, the phenomenon of homœomorphy was discovered, and the reception accorded to homœomorphy has at any rate been cordial. But it involves a revision, almost a rewriting, of palæontology. Much of my earlier work I have revised; much of it I should like to rewrite.

Such spade-work finds perhaps its fullest expression in the publication *Yorkshire Type-Ammonites*; for the bed-rock of nomenclature must be an exact knowledge of types. And I cannot let this opportunity pass without acknowledging the debt which I owe to my enthusiastic collaborator, Mr. J. W. Tutcher, who combines an excellent geological knowledge with unrivalled photographic skill. His work has been the making of that publication.

To you, sir, and to the Council I tender my heartfelt thanks for an award which encourages me to continue my researches.

The President then presented the Bigsby Medal to Sir Thomas Henry Holland, K.C.I.E., addressing him in the following words:—

Sir Thomas Holland,—The Council have awarded to you the Bigsby Medal in recognition of the eminent services which you have rendered to geology, more especially during your tenure of office in India. Appointed to the Geological Survey of India in 1890, you proceeded to enrich the Records and other publications, not only with papers on petrological and other scientific questions, but with the discussion of problems more directly bearing on the welfare and safety of the inhabitants of India. Under your Directorship, from 1903 to 1909, the Geological Survey of India maintained its high reputation; while, at the same time, advantage was taken of your sagacity and extended geological experience to obtain your advice in the administration of Indian scientific affairs.

It is not possible for me to refer in detail to your published works. They range from petrology, mineralogy, stratigraphy, and seismology into the domain of geography, one of your latest papers having been devoted to an account of the remarkable dissemination of salt which can be effected by wind. But I may emphasize, in the words of the founder of this Medal, the fact that you are not too young to have done much, and that you are not too old for further work. It is the hope of the Council that you will continue for many years at home the eminently useful career which you have commenced so auspiciously in India.

Sir Thomas Holland replied as follows:—

I deeply appreciate the honour which has been conferred on me by the Council, as well as the generous terms in which you, sir, have referred to my work. Nothing could be more pleasing to a worker than to be enjoined by one's seniors to continue in work.

A glance over the list of my distinguished predecessors shows how abundantly each one subsequently fulfilled the intention of this award, and thus one's feelings of satisfaction become tinged with those of great responsibility. At the same time, when one realizes that the Council hitherto has never made a mistake in its selection of a recipient for the Bigsby Medal, this feeling of responsibility becomes again blended with that of hopeful ambition.

In so far as this honour is a recognition of work already done, I should like to make it known to the Council that my chief aims in India have been to facilitate the work of my colleagues. No published work of my own has caused me more anxious care, or given me greater satisfaction, than the memoirs issued in the names of my colleagues on the Geological Survey of India; it was because of their abundantly loyal support that a measure of success followed my administration, and it is because this honour in effect recognizes their good work that it gives me peculiar pleasure.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. William Wickham King, F.G.S., the President addressed him as follows:—

Mr. Wickham King,—The Council have awarded to you the Wollaston Fund, to mark more especially their appreciation of your researches on the Permian Conglomerates of the Lower Severn Basin. Probably no group of British deposits called more urgently for investigation than the red rocks of the Midlands. Their remarkable conglomerates, breccias, and calcareous bands offered problems of the greatest interest; while the stratigraphical sequence and correlation throughout the country called for reconsideration. Though the story is not yet fully told, your paper marked a notable advance in its elucidation; the Permian breccias of the Severn Valley are inseparably connected in men's minds with your name.

The Council are aware that you are engaged upon other problems connected with the district in which you have laboured to such advantage, and make this award, not only in recognition of what you have done, but in anticipation of equally good work to follow.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Ernest Edward Leslie Dixon, B.Sc., F.G.S., addressing him in the following words:—

Mr. Dixon,—The Murchison Fund has been awarded to you by the Council of our Society to mark their sense of the value of your detailed observations on the Carboniferous Limestone. Working in association with Dr. Vaughan, and armed with the knowledge which you had gained during your official survey of the region, you were able to combine detailed palæontological and stratigraphical observations in such a manner as to produce an exhaustive account of the varying geographical conditions under which the limestone of Gower came into existence. You have also provided us with an admirable account, founded in part upon your own observations, of the remarkable overfolds exhibited in the Pyrenees. May I be permitted to add, from my own knowledge of a colleague with whom I have long been associated, my testimony to your zeal and to that carefulness in field-work which leaves no stone unturned and no note unmade. The Council in making this award anticipate with confidence further results from your labours.

In presenting the Balance of the Proceeds of the Lyell Geological Fund to Mr. Llewellyn Treacher, F.G.S., the President addressed him as follows:—

Mr. Treacher,—The Council have awarded to you the Lyell Fund in recognition of the value of your contributions on the Chalk. In 1905, in association with Mr. Osborne White, you were able to add greatly to our knowledge of the fauna and zonal affinities of the Taplow phosphatic chalk. In the following year, with the same collaborator, you described some occurrences in Berkshire of phosphatic chalk not previously known, and also published the result of your joint investigations on the Upper Chalk of the western end of the London Basin, showing in detail the extent of the Tertiary transgression. While thus engaged you have not omitted to collect the relics which Neolithic and Palæolithic men have left in the Thames Valley. For my own part I take this opportunity of acknowledging the great utility of such observations as yours in the work of the Geological Survey. We look forward to the continuance of your researches.

The President then presented a Moiety of the Proceeds of the Barlow-Jameson Fund to Bernard Smith, M.A., addressing him as follows:—

Mr. SMITH,—In awarding to you a part of the Barlow-Jameson Fund the Council have borne in mind that our knowledge of the glacial phenomena of Black Combe is largely due to your researches. In your admirable account of that region every branch of the inquiry has received due consideration; but your description of channels now for the most part abandoned, though occupied during the Glacial Period by marginal streams or overflows, forms a special feature of your paper. In the course of your official work in Nottinghamshire you have made good use of your opportunities to study the remarkable skerry-bands of the Keuper Marl, and found reason to connect their formation with the variations of the seasons. Lower Palæozoic rocks also have engaged your attention in Ireland.

This award has been made in the expectation that you will continue the career so well begun, and will do yet more "for the advancement of geological science".

In handing the other Moiety of the Proceeds of the Barlow-Jameson Fund, awarded to John Brooke Scrivenor, M.A., to Mr. Clement Reid, F.R.S., for transmission to the recipient, the President addressed him in the following words:—

Mr. REID,—In the course of a rapid journey in Patagonia, Mr. Scrivenor found time to make observations on the sedimentary and igneous rocks and on the river-system of that country. From 1902, as a member of the staff of the Geological Survey, he was associated with you in Cornwall, and rendered valuable assistance in preparing the maps and memoirs illustrating the country around Newquay and the Land's End. In 1905 he was selected as Government Geologist in the Federated Malay States, and since his appointment has enriched our knowledge of that difficult region by papers on the mode of occurrence and mining of gold, tin, copper, and other ores, by descriptions of Archæan and igneous rocks, and by researches on the sedimentary sequence. Both in range of subject and in extent of travel he has distinguished himself as one of our leading exponents of the geology of the more distant parts of the Empire.

In transmitting to him a part of the Barlow-Jameson Fund, will you assure him that we at home watch with interest the work of our colleagues abroad, and will you express on our behalf the hope that he may long preserve the energy necessary for the prosecution of such arduous labours?

The President thereafter proceeded to read his Anniversary Address, giving Obituary Notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last Annual Meeting, including Professor G. J. Brush (elected a Foreign Member in 1894); Professor F. Zirkel (el. 1880); Professor F. A. Forel (elected a Foreign Correspondent in 1910); Professor K. von Krustshov (el. 1895); Professor E. von Koken (el. 1900); Professor R. S. Tarr (el. 1909); J. Dickinson (elected a Fellow in 1842); Dr. R. H. Traquair (el. 1874); R. Bruce Foote (el. 1867); J. Parker (el. 1867); Captain A. W. Stiffe (el. 1874); Dr. J. Morison (el. 1887); W. H. Pickering (el. 1907); Sir Charles Whitehead (el. 1872); and Dr. J. S. Phené (el. 1887).

As the main object of his Address, the President discussed the form of that part of the Palæozoic platform which underlies the Secondary rocks of the South-East of England. Upwards of forty borings have been carried down to it, and have provided sufficient evidence for the construction of a contoured map of parts of it. Two regions are still unknown, namely the southern counties and a tract extending north-westwards from the estuary of the Thames; but, between the two, contour-lines at 500, 1,000, and 1,500 feet below sea-level can be drawn for considerable distances. The form of the platform thus illustrated shows no connexion with its geological structure, so far as that is known, and may be attributed to planation, for the most part by marine action, and to warping by the post-Oligocene movements which produced the dominant structure of the South-East of England.

To illustrate the effect of these movements a second map is constructed, showing contour-lines in the base of the Gault at intervals of 500 feet, extending from 500 feet above the sea to 2,500 feet below it. The result is to give a comprehensive view of the warping undergone by the Upper Cretaceous and Tertiary rocks and of the magnitude of the movements. The height above sea-level to which the base of the Gault has been raised, and the depth below sea-level to which it has been depressed, can be estimated approximately at every point from the contouring. It thus becomes possible to see what corrections are necessary to restore the base of the Gault to horizontality, and thus to eliminate the effects of the post-Oligocene movements.

By making this correction in the first map, the Palæozoic platform is restored to the form that it possessed before those movements came into operation. A third map, thus constructed, shows that considerable changes were effected. A tract of high elevation clearly defines itself under London and near Harwich. On the northern and southern sides the contour-lines run with much regularity, and those on the south give evidence of a bold slope continuing downwards far in that direction. It appears that the London Syncline has come into existence in an area that was long one of elevation, and that the Wealden Anticline has been superimposed upon a region of depression.

It is further pointed out that, for a continuance of these investigations, we are dependent upon the making of borings for coal or water; but that no machinery has been created for the systematic registration of borings, notwithstanding the recommendation made in the Report of the Royal Commission on Coal Supplies. The information gained in a borehole may come to hand by chance, or it may be lost. Frequently no permanent record is kept of the site, diameter, or depth of boreholes.

It is noted with pleasure that a precise levelling is being carried out by the Ordnance Survey to replace the levelling made in 1841 to 1859, which was not of modern precision, and was recorded by marks which were not permanent. It is pointed out that in work of the precision contemplated factors of unknown value may have to be taken into account, such for example as earth-tides or the effect of the oceanic tide upon coastal regions, but more especially the variations in gravity which are known to exist, although they have never been systematically examined in the British Isles. Observations are in progress in India and in many foreign countries; but in our own country they ceased at a critical stage. The early observers in the middle of the last century became aware of the existence of the variations, and, while experimenting on the deflection of the plumb-line caused by mountain-masses such as Schiehallion and Arthur's Seat, found reason to conclude that deflection was caused also by variations in the specific gravity of underground rocks.

There is some reason for believing that lines of equal gravity may have some connexion with magnetic 'ridge-lines'. It has been recently recommended that the Magnetic Survey of 1891 should be repeated. It is suggested that a Gravity Survey is equally desirable. The British Isles, in virtue both of their geographical position on the margin of the European Continent, and in virtue of the form and structure of the Palæozoic platform, appear to constitute a region eminently suited for such an investigation.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—

OFFICERS:—*President:* Aubrey Strahan, Sc.D., F.R.S. *Vice-Presidents:* Professor Edmund J. Garwood, M.A.; Richard Dixon Oldham, F.R.S.; Clement Reid, F.R.S., F.L.S.; Professor W. W. Watts, Sc.D., M.Sc., F.R.S. *Secretaries:* A. Smith Woodward, LL.D., F.R.S.; Herbert Henry Thomas, M.A., B.Sc. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer:* Bedford McNeill, Assoc.R.S.M.

The other Members of COUNCIL elected were:—Henry A. Allen; Henry Howe Bemrose, J.P., Sc.D.; Professor Thomas George Bonney, Sc.D., LL.D., F.R.S.; James Vincent Elsden, D.Sc.; John William Evans, D.Sc., LL.B.; William George Fearnsides, M.A.; Professor Owen Thomas Jones, M.A., D.Sc.; Herbert Lapworth, D.Sc., M.Inst.C.E.; Horace W. Monckton, Treas.L.S.; Edwin Tulley Newton, F.R.S.; George Thurland Prior, M.A., D.Sc., F.R.S.; Arthur Vaughan, M.A., D.Sc.; William Whitaker, B.A., F.R.S.; Rev. Henry Hoyte Winwood, M.A.

February 26, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Geology of Bardsey Island (Carnarvonshire)." By Charles Alfred Matley, D.Sc., F.G.S.; with an Appendix on the Petrography by John Smith Flett, M.A., D.Sc., F.G.S.

Bardsey, an island a mile and three-quarters long, lies off the promontory of the Lleyn (Western Carnarvonshire), and forms the isolated extremity of the strip of pre-Cambrian rocks that borders the western coast of the Lleyn from Nevin south-westwards.

The rocks are principally gritty schistose slates, with many thin and some thick bands of grit, quartzite, and limestone; and they contain an horizon of variolitic lava and tufaceous shale, which indicates that a volcanic episode took place during their formation. Sills of albite-diabase also occur, as well as one or more sills of a crushed granite.

The rocks have been subjected to intense earth-pressure acting mainly from the north-west, and are mostly in a cataclastic condition, the harder rocks being almost always torn up into lenticles. The beds are shown to be arranged on the whole in a number of isoclinal folds, complicated by overthrusting, shearing, and brecciation. Stages in the formation of crush conglomerates are described. From the nature of the brecciation and the comparatively small amount of mineral alteration that the beds have undergone, it is inferred that the load of superincumbent rock at the time of the principal earth-movements was not great.

The rócks are correlated with the lower portion of the Llanbadrig Beds and with the Llanfair y'nghornwy Beds of Anglesey, and they agree also with their Anglesey representatives in the manner in which they have been affected by earth-movement.

Some post-movement dykes of olivine-dolerite occur, with a north-west to south-east trend. They are probably of Tertiary age.

Glacial striæ and boulders indicate that the island was invaded by a portion of the Irish Sea ice-sheet, which, after crossing Anglesey to the west of Red Wharf Bay in a south-westerly direction, was deflected in Carnarvon Bay and traversed Bardsey in a south-easterly direction. This direction is tentatively attributed to the pressure of ice radiating from Ireland.

There are doubtful indications of a post-Glacial raised beach at 18 to 20 feet O.D.

In an Appendix Dr. J. S. Flett describes the petrographical characters of the granites, the pillow-lavas and their tuffs, and the diabases.

2. "The Loch Awe Syncline (Argyllshire)." By Edward Battersby Bailey, B.A., F.G.S.

Mr. J. B. Hill's classification of the sedimentary schists of the district, into the Loch Awe Group above, and the Ardrishaig Group below, is accepted. So also is his reading of the Loch Awe Syncline. This syncline is a comparatively shallow trough, with well-marked fan-structure due to small-scale isoclinal folding, in which the limbs of the folds are vertical along the axial belt of the syncline, and inclined outwards on either side.

There are, however, two modifications of Mr. Hill's original interpretation, both of them already dealt with, in part, by Dr. B. N. Peach and the author in the Geological Survey memoir describing the southernmost portion of the region (Sheet 28). One of the proposed alterations is concerned with the numberless igneous rocks folded along with the sedimentary schists. Many of these are obvious intrusions; but some, as Dr. Peach showed in 1903, are certainly lavas. In the present paper Dr. Peach's volcanic zone is traced throughout the whole district, where it maintains a constant horizon in the Loch Awe Group. This brings us to the second suggested modification, affecting, as it does, details of the stratigraphy of the Loch Awe Group, for which the following sequence is proposed:—

Loch Avich Green Slates and Grits (volcanic rocks in the lower part).
Tayvallich Black Slates and Limestones (volcanic rocks throughout).
Crinan Grits and Quartzites.
Shira Limestone, constituting a passage-zone down into the Ardrishaig Phyllites.

Attention is drawn to evidence, already published, that the order of superposition of the sediments in the Loch Awe Syncline corresponds with the original order of sedimentary superposition. Finally, a recent suggestion of Mr. Hill's is adopted, in which he correlates the extremely low grade of metamorphism of the rocks of the central part of the Loch Awe Syncline with their high structural position. The hypothesis is that these rocks were not deeply covered during their metamorphism, and accordingly were never raised to any very high temperature.

CORRESPONDENCE.

CRITICAL TEMPERATURES AND CRITICAL CONTROVERSY.

SIR,—Referring to Dr. Johnston-Lavis' letter, I am sorry if I have failed to do him jûstice. I have a list of eighty of his papers to 1890, none, however, bearing on critical temperatures. If he will send me references to any subsequent ones bearing on the action of superheated water I shall be obliged.

And now I must throw myself on your Editorial leniency and that of your readers.

On the day I received the proofs of the article which appears this month I suffered a serious nervous collapse, and am under strict orders to spare myself in every way, and this just at a moment when the Survey Memoir of Dartmoor makes it incumbent on me to review nearly thirty years of observation of that district; and Mr. Jukes-Browne's papers on "The Making of Torbay" and on "The Torquay Limestones" do the same for about forty years' reflections on the raised beaches and general geology of that district! In addition to this there is a good deal that wants saying about Kent's Cavern.

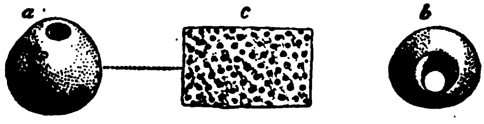
I am very sorry to have broached subjects in your columns which I cannot for the moment now defend, in critical controversy, but I will try to meet any objections, or yield to them, if possible later on. If not in this Magazine, then somewhere else.

A. R. HUNT.

SOUTHWOOD, TORQUAY.
March 7, 1913.

PREHISTORIC BEADS.

SIR,—As a supplement to my letter in the GEOL. MAG. for March, p. 138, and your reply thereto, pp. 139–43, I send you the following quotation from Sir Charles Lyell's *Antiquity of Man* (4th edition, p. 165). He writes as follows: "In the gravel-pits of St. Acheul, and



a, b, Porosphæra globularis, Phillips, copied from Lyell's *Antiquity of Man*, 4th ed., p. 165, fig. 22, 1873; *c*, part of same magnified.

in some others near Amiens, small round bodies, having a tubular cavity in the centre, occur. They are well known as fossils of the White Chalk. Dr. Rigollot suggested that they might have been strung together as beads, and he supposed the hole in the centre to have been artificial. Some of these round bodies are found entire in the chalk and in the gravel, others have a hole passing through them, and sometimes one or two holes penetrating some way in from the surface, and not extending to the other side. Others, like *b* in Figure, have a large cavity, which has a very artificial aspect. It is impossible to decide whether they have or have not served as personal ornaments, recommended by their globular form, lightness, and by being less destructible than ordinary chalk. Granting that there were natural cavities in the axis of some of them, it does not follow that these may not have been taken advantage of for stringing them as beads, while others may have been artificially bored through. Dr. Rigollot's argument in favour of them having been used as necklaces or bracelets appears to me a sound one. He says he often found small heaps or groups of them in one place, all perforated, just as if, when swept into the river's bed by a flood, the bond or string which had united them together remained unbroken.[1]"

J. T. Banton.

Kingston Rectory,
Cambridge.

OBITUARY.

RUSSELL FROST GWINNELL,
B.Sc., Assoc. R.C.Sci., F.G.S.

Born April 21, 1880. Died March 15, 1913.

We deeply regret to record the death of Mr. R. F. Gwinnell, at the early age of 33 years. He had been for some years Demonstrator in Geology under Professor W. W. Watts, F.R.S., in the Imperial College of Science and Technology, South Kensington, and also an Examiner in Geology to the Board of Education. Mr. R. F. Gwinnell was a bachelor living at home with his parents, his father, Mr. Wintour F. Gwinnell, B.Sc., F.G.S., 34 Barrowgate Road, Chiswick, W., being a well-known University 'coach' and an accomplished science teacher of long standing.

MALCOLM POIGNAND.

Born 1850. Died March 2, 1913.

We regret to record the death on March 2, in his 63rd year, of Dr. Malcolm Poignand, of the Beeches, Walsham-le-Willows, Suffolk. He was a member of the Geologists' Association, and took an active interest in geology, having collected many fossils from the Jurassic strata of Dorset and other formations, some of his specimens being referred to in the Proceedings of the Association (vol. ix, p. 204). He received his medical education at St. Bartholomew's Hospital, and subsequently at Aberdeen University, where he took the degree of M.D. in 1878.

"[1] Rigollot, Mémoire sur des Instruments en Silex, etc., p. 16. Amiens, 1854."

MISCELLANEOUS.

The Thomas Pennant Collection of Fossils.

Some published notices have recently appeared calling attention to the natural history collections of Thomas Pennant, formed a century and a half ago, which have been generously presented to the British Museum by the Right Honourable the Earl and Countess of Denbigh, of Downing, Flintshire, Pennant's birthplace and home, where the collections have lain since his death in 1798. As no mention has been made of the fossils, which form an important part of this gift, it seems necessary to make a statement on the subject. These fossils comprise upwards of a thousand specimens, including the remains of Vertebrates, Mollusca, Brachiopods, Crustacea, Corals, and other groups of organisms from various geological horizons of both British and foreign localities. Many of the specimens bear a number having reference to a manuscript catalogue where brief descriptions are given. The main title of this volume is somewhat quaint, and reads as follows: *Reliquiæ Diluvianæ, or a Catalogue of such Bodies as were deposited in the Earth by the Deluge.* On the back is printed in gilt letters "Extraneous Fossils, vol. 3". A few of the fossils are distinctly interesting from the fact that they have been either figured or mentioned in literature; and particularly is this the case in connexion with three small Wenlock Limestone corals from the Coalbrookdale area of Shropshire. These were described and figured by Pennant in one of his earliest published papers of the *Philosophical Transactions* (Royal Society), vol. xlix, pt. ii, pl. xv, figs. 1, 3, 4, pp. 513, 514, 1757, entitled "An Account of some Fungitæ and other Coralloid Fossil Bodies"; such specimens being now recognized under the genera *Favosites* and *Actinocystis*. There is also a Mammoth tooth which is referred to in his *Synopsis of Quadrupeds*, p. 90 (1771), as having been found in a bed of gravel beneath a thick limestone, "at the depth of 42 yards in a lead-mine in Flintshire."

Thomas Pennant (1726–98) was a naturalist of considerable reputation, having been a contemporary and correspondent of Linnæus, and a close friend of Gilbert White, whose letters forming *The Natural History of Selborne* were mostly addressed to "Thomas Pennant, Esq." He was the author of numerous works on natural history, such as *The British Zoology* (1766), *Genera of Birds* (1773), *History of Quadrupeds* (1781), etc., some of which reached several editions.

It may be of interest to add that a small selected series of these fossils is now exhibited in one of the Museum table-cases of the Geological Department, in company with the Hans Sloane, the Brander, and other historical collections; the remainder are arranged in the cabinet drawers beneath. The manuscript catalogue is deposited in the library of the same department.

R. B. N.

The Croonian Lecture.—Dr. R. Broom, of South Africa, has been chosen by the Royal Society to deliver the Croonian Lecture.

THE
GEOLOGICAL MAGAZINE
NEW SERIES. DECADE V. VOL. X.

No. V.—MAY, 1913.

ORIGINAL ARTICLES.

I.—On some Bird Remains from the Upper Cretaceous of Transsylvania.[1]

By C. W. Andrews, D.Sc., F.R.S. (British Museum, Natural History).

SO long ago as 1897 Baron Franz Nopcsa[2] recorded the discovery of numerous bones of Dinosaurs and Chelonians in freshwater deposits of Upper Cretaceous age at Szentpeterfalva in Transsylvania. Since that time he has made extensive collections of bones from the same locality and has published various papers concerning them. In his last collection, now in the British Museum (Natural History), there occur some fragments of limb-bones which he does not consider to be reptilian but rather of avian origin. These specimens he has kindly submitted to me for determination and description, and they form the subject of the present paper.

The limb-bones of which portions have been obtained are the femur and tibio-tarsus. The femur is represented by two imperfect specimens: of these, one consists of the upper end and about the proximal fourth of the shaft (Fig. 1), almost uncrushed and altogether in a very good state of preservation; the other includes the upper end and the greater part of the shaft, but in this case the bone has been much crushed and broken and the head and other prominences considerably abraded.

The head of the femur (*h.*) is large and would be nearly hemispherical if it were not for the large circular fossa for the attachment of the *ligamentum teres* (*l.t.*), situated rather towards the posterior side of the head and looking inwards and backwards. Ventrally the head is marked off by a well-defined groove, but above its surface passes into that of the great trochanter (*tr.*), the two being separated by a slight concavity only. The head as a whole is directed slightly upwards, rising a little above the trochanteric surface. This latter is gently convex and roughly triangular in outline, its most prominent angle projecting strongly forwards and inwards. The posterior angle is less prominent and is truncated by a deep muscle impression (*o.m.*), probably for the attachment of the obturator muscles. Beneath the trochanteric surface the anterior face of the bone is concave, the concavity being bounded above by the rather prominent anterior edge of the trochanter, and externally by a strongly developed forwardly directed ridge running down from the antero-external angle. The lower end of this ridge is continued

[1] Published by permission of the Trustees of the British Museum.
[2] Verhandl. d. k. k. geol. Reichsanstalt (Vienna, 1897), p. 273.

on to the anterior face of the shaft as a strongly marked *linea aspera*, which runs downwards and obliquely across towards the inner distal condyle; its full extent cannot be seen on account of the incompleteness of the distal end of the specimen. This ridge probably marks the line of insertion of the femoro-tibial muscles. The outer face of the trochanter is concave, owing to the presence of deep pits for the insertion of muscles, probably the *gluteus medius* and the *gluteus externus*. The surface truncating the posterior angle of the trochanter and probably serving for the attachment of the obturator muscles has already been referred to.

Beneath the trochanteric region the bone narrows to a shaft which is oval in section, the transverse diameter being a little the greater. The muscular ridge on the anterior face has already been referred to, and there is another strong *linea aspera* (*l.a.*) on the hinder face, beginning just beneath the trochanter and running downwards and outwards, apparently towards the outer condyle, and becoming very strongly marked at its lower end. There is some evidence that towards its lower end the shaft curved considerably backwards.

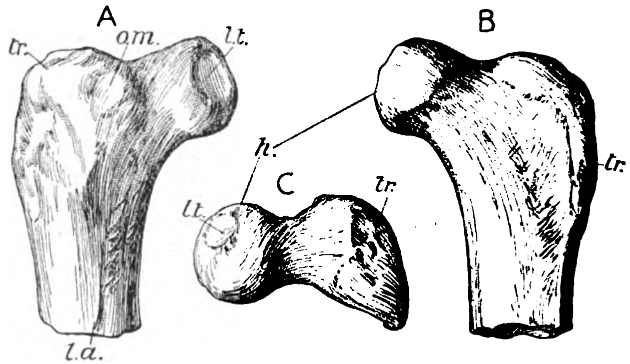


FIG. 1. Upper end of left femur of *Elopteryx nopcsai*, gen. et sp. nov. A, from behind; B, from the front; C, from above. Type-specimen, $\frac{2}{3}$ nat. size. *h.* head of femur; *l.a. linea aspera*; *l.t.* pit for the insertion of the *ligamentum teres*; *o.m.* point of insertion of the obturator muscles; *tr.* trochanter.

In the uncrushed specimen the fractured end shows that the wall of the shaft consists of a hard compact outer layer measuring from 3·5 mm. in thickness at the front and back to about 6·5 mm. at the sides. Within this there is a spongy layer of indefinite thickness enclosing a central cavity. Judging so far as is possible from the crushed specimen, the central cavity is larger towards the lower end of the shaft, the spongy layer being less developed, while the outer hard layer also is thinner. The outer surface of the bone is sculptured in a remarkable way, being raised into a series of fine wrinkles which are for the most part irregular and run into one another, though in some places, as for instance on parts of the anterior face of the trochanter, they may be more or less parallel, and in that case, as a rule, they run more or less in the direction of the long axis of the bone. A similar sculpture may be seen on some bird-bones, e.g. on the femur of *Phalacrocorax* and to a less extent in *Pelecanus*, but in these cases it is less distinctly seen, being partly masked by the presence of organic matter which has been removed in the fossils. Similar sculpture occurs on the fragment of a tibio-tarsus described below. This peculiarity in the texture of the surface of the bone, taken together with the similarity of form of these femora with those of some recent birds, even in details of muscle attachment and of the disposition of the *lineæ asperæ*, seems to leave no doubt as to the avian nature of these remains.

A fairly exhaustive comparison of these portions of femora with those of various groups of recent birds leads to the conclusion that, so far as the evidence available goes, there is reason to believe that these extinct forms approach most nearly to the Steganopodes, e.g. the cormorant (*Phalacrocorax*). The points of similarity are (1) the form of the great trochanter, especially the strong forward prominence of its antero-external angle, (2) the position and depth of the muscle impressions on the outer face of the trochanter, (3) the fact that the summit of the head rises above the trochanter, (4) the large

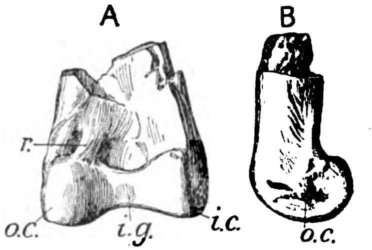


FIG. 2. Distal end of the right tibio-tarsus of (?) *Elopteryx nopcsai*. A, from front; B, from outer side. ⅔ nat. size. *i.c.* inner condyle; *i.g.* intercondylar groove; *o.c.* outer condyle; *r.* outer ridge.

size of the pit for the *ligamentum teres*. Furthermore, the arrangement of the muscular ridges, at least in the upper part of the shaft, is closely similar to that seen in the Steganopodous femur, as is also the tendency to a backward flexure of the lower part of the bone. The bird represented by the remains just described was about as large as a pelican and is certainly different from any previously known form. I propose that it should be called *Elopteryx nopcsai*, gen. et sp. nov.

Another specimen which seems to belong to a bird is the distal end of a right tibio-tarsus (Fig. 2), including the articular region and about two centimetres of the lower end of the shaft; both the articular end and the shaft are strongly compressed from before backwards. The articular surface consists of two sub-equal condyles, the outer (*o.c.*) being a little the more prominent and convex; these are separated by a deep intercondylar groove (*i.g.*), bounded above by a narrow shelf of bone which forms the floor of a deep fossa at the lower end of the anterior face of the shaft. The condyles project very little posteriorly, and pass by a continuous curve into the flat or very slightly concave posterior face of the shaft; the trochlear surface of the inner condyle (*i.c.*) extends a little higher up than that of the outer. The fossa on the anterior face of the shaft is bounded internally by a slight ridge, while on its outer side there is a strong flattened ridge (*r.*) running obliquely down to the upper border of the outer condyle, and perforated by a very narrow passage directed obliquely downwards and inwards. This passage is too narrow to represent the channel for the extensor tendons, present in most birds, and moreover is not in the right position. A similar foramen is present in many birds of very different groups, e.g. *Didus* and *Dinornis*; probably it transmitted a blood-vessel. The outer face of the external condyle bears a deep rounded fossa towards its anterior border, and behind this there is a narrow deeply cut pit, both probably serving for the attachment of strong ligaments. The inner face of the inner condyle is also excavated for the attachment of ligament, but the cavity is comparatively large and shallow. Above the inner condyle on the side of the shaft there is a roughened depression for the attachment of a muscle. No very closely similar form of tibio-tarsus has been found among recent birds. The fact that the condyles are nearly equal in size and that one does not project below the other separates this tibia widely from that of *Phalocrocorax*, and gives the impression that the bird was not adapted for swimming, but was ambulatory. It is of course uncertain whether this tibia belongs to the same bird as the femora described above, but from the close similarity of the sculpturing of the surface of the bone in the two cases it seems most probable that this is the case. If that is so, the resemblances found to exist between the femur of *Elopteryx* and that of *Phalocrocorax* lose some of their value, and it appears possible that the deep muscle impressions on the trochanter of the femur, though indicating a very powerful limb, do not necessarily point to an aquatic mode of life. Much more material must be obtained before it is possible to ascertain the affinities of *Elopteryx*, but that a large bird existed in Transsylvania at the close of the Secondary period and in association with *Mochlodon*, *Telmatosaurus*, and other Dinosaurs is certain. It is not the occurrence of birds at this horizon that is remarkable, but the extreme rarity of their remains, while their complete absence from such deposits as the Purbeck and Wealden is still more extraordinary. The few remains that have been found in the later Secondary rocks show that the group was already highly differentiated, and in the Eocene probably all the chief orders now existing were already established.

II.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the March Number, p. 99.*)

(PLATE VII.)

THERE are a number of simple Cheilostomata which develop avicularia distinctly larger than the zooecia and more or less constricted in the middle by prominent masses apparently due to infolds of the side walls. *Eschara Lesueuri*, Hag., sp.,[1] is a good example, and others have been figured by D'Orbigny. Similar forms are not uncommon in the English Chalk, but it is curious that all the foreign forms seem to be of branching Biflustrine habit, while all the English species I have yet met with form unilaminate sheets.

MEMBRANIPORA GRAVENSIS, sp. nov. Pl. VII, Figs. 1, 2.

Zoarium unilaminate, always adherent.

Zoœcia large, subpyriform, with distinct side walls and a variable amount of internal front wall, in consequence of which the areas vary from slightly elliptical to practically semicircular, but the lower lip of the area never becomes convex.

Oœcia helmet-shaped, large and wide, with a gently convex free edge.

Avicularia about half as long again as the zoœcia; above the constricting prominence they possess fairly definite side walls and front walls; these side walls thin away against the adjoining zoœcia, and their bounding sutures are very hard to trace; the front walls are fairly wide and very deep-set at the head, but narrow gradually and rise steadily towards the middle; the infold of the side wall starts a long way below the level of the upper end of the area, is bold and runs with a slightly convex edge obliquely inwards until it overlies the edge of the rising front wall, and then the two edges appear to run together, meeting a little further down and inwards; the junction is made into a small, rather brittle, projecting point by the sharp cutting-back immediately below it of the upper part of the mass, which then passes rapidly into a rounded side wall with a steeply sloping inner surface, which flattens out until at the foot the avicularium is subpyriform like the zoœcium; the area is naturally marked off by the constricting prominences into an upper and a lower section, the upper being much the larger. Avicularia are rarely developed until the zoarium has attained a considerable size, and it is therefore difficult to distinguish small zoaria from the mass of featureless specimens which it is customary to identify with some simple living *Membranipora*, but which are probably incapable of satisfactory identification.

This species is at present known to me only from the zone of *M. cor-anguinum* at Gravesend, where it is rather scarce.

MEMBRANIPORA SPARKSI, sp. nov. Pl. VII, Figs. 5–8.

Zoarium unilaminate, always free and foliaceous.

Zoœcia normally hexagonal and equilateral, with well-marked boundary sutures, thick flat walls, and slightly elliptical areas, but very variable at times both in shape and size; at the head of the zoœcium there is suddenly developed a narrow deep-set internal front wall, which is very characteristic.

Oœcia rare, but strong and well preserved, helmet-shaped and wide, with a free edge only slightly concave.

Avicularia very sparse in occurrence, of the same general type as in *M. Gravensis*, but with a strong tendency, both in external and

[1] Hagenow, *Die Bryozoa der Maest. Kreideb.*, p. 72, t. viii, fig. 17, and t. xii, fig. 12.

areal outline, to be long and parallel sided with pointed ends; at the head the side wall has a slight but definite thickness; the infold of the side wall has a concave edge, which never quite hides the edge of the front wall, and it can be clearly seen that these edges unite in the projecting point; the lower end of the avicularium is (in correspondence with the zoœcia) simple, not subpyriform; the upper and lower sections of the area are approximately of equal size.

The basal lamina is distinctive and apparently so constant in form as to be reliable for purposes of diagnosis, and I have figured a small piece.

This species is well distributed in the (restricted) zone of *A. quadratus* in Hants, and is abundant in Sparks' Pit, near Cosham.

MEMBRANIPORA CERVICORNIS, sp. nov. Pl. VII, Figs. 3, 4.

This species, which succeeds *M. Sparksi* very closely in time, is naturally very closely related to it, and is perhaps best described by enumerating the points in which it differs from that species. It is always adherent; the zoœcia have rounded side walls and no internal front wall; the avicularia and their areas tend to be short, broad, and round-ended, the front wall is very wide, the upper section of the area is smaller than the lower, and the constricting prominences stand up very strongly and have flowing outlines suggestive of those of a deer's antlers; no traces of oœcia have yet been observed.

This species occurs sparingly in the base of the zone of *B. mucronata* at Portsdown.

MEMBRANIPORA PLICATELLA, sp. nov. Pl. VII, Fig. 9.

Zoarium unilaminate, free or adherent, the free specimens showing a strong tendency to tubular branching shapes, as if they had incrusted seaweeds.

Zoœcia elongated, roughly hexagonal, with a considerable amount of internal front wall at the foot and bounded by definite sutures; areas of very variable size, but relatively small, roughly oblong, with gently convex sides.

Oœcia not yet observed.

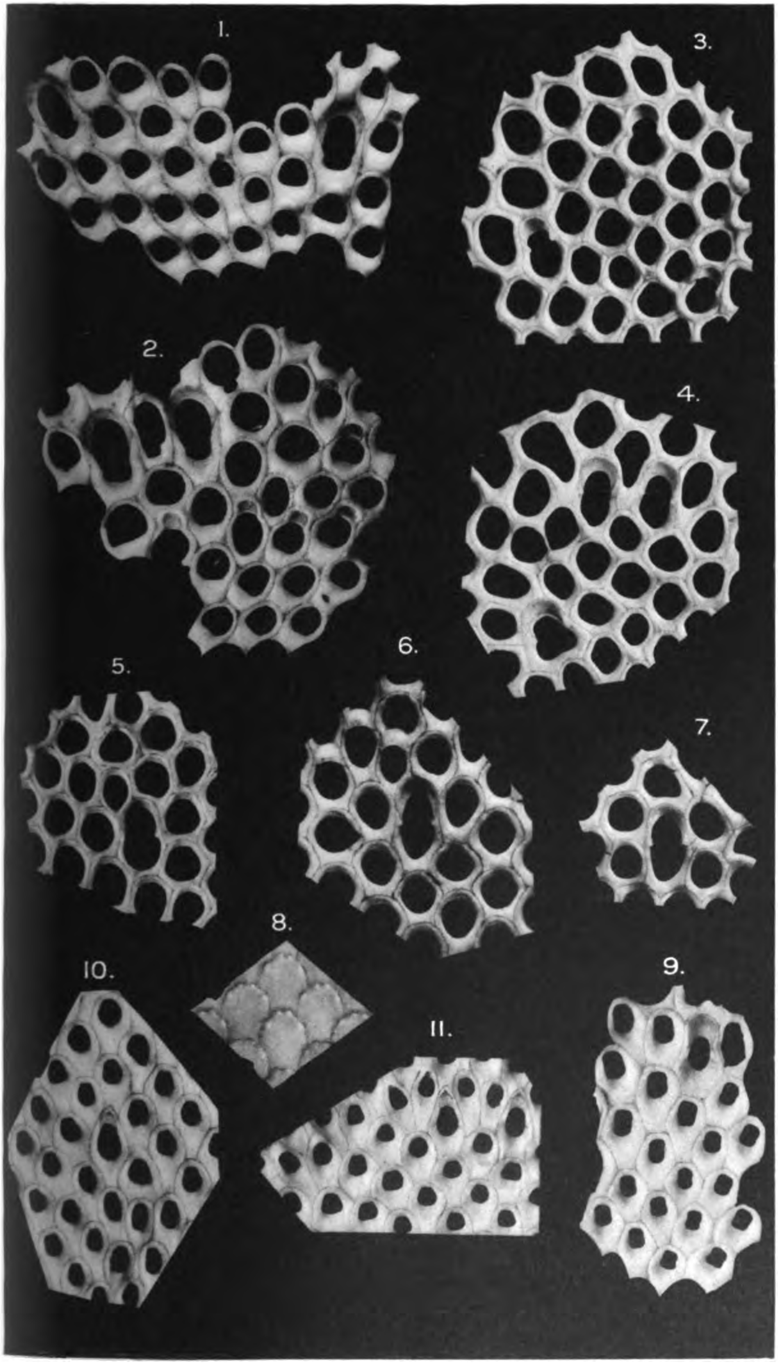
Avicularia relatively very large, of general *Lesueuri*-type; there is practically no distinction between front wall and side wall at the head, the two combining into a bowl-shaped ending; the edge of the infold of the side wall seems to split into an upper and a lower lamina, the upper one being cut back very early and dying out; the area is relatively very small, being little larger than that of the larger zoœcia, and narrowly elliptical, and the constricting prominences, which practically do not impinge on it, are median in position.

This species is fairly abundant at Trimingham.

MEMBRANIPORA ÆDIFICATA, sp. nov. Pl. VII, Figs. 10, 11.

Zoarium unilaminate, always adherent.

Zoœcia long and narrow, with flowing outlines and separated by faint sutures; areas very variable in size but relatively very small and situate quite in the upper half of the zoœcia, wide and flatly



R. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.

rounded at the lower end and narrowing gently upwards, usually with obtuse angles at the upper corners due to the arising of a very slight straight-edged internal front wall at the head.

Oœcia abundant, rather fragile, consisting of gentle helmet-shaped swellings with concave free edges.

Avicularia with very faint boundaries, rather modified from the general *Lesueuri*-type; the infold of the side walls starts well above the level of the top of the area and runs downwards with a straight edge until it impinges slightly on the area close to its upper end and forms the constricting prominence, which is thus exceptionally far up the avicularium; the cutting-back below is very slight, though discernible; upwards from the point where the infold starts the side walls are straight and well marked and slope inwards to meet in an acute angle, like roof timbers, so that the outline of the front wall is that of a cross-section through a simple building; the area is a narrow ellipse, and, as indicated, the upper section of the area is very small, the lower very large.

This species is well represented at Trimingham.

EXPLANATION OF PLATE VII.

(All figures × 12 diams.)

Figs. 1, 2.	*Membranipora Gravensis.*	Zone of *M. cor-anguinum,* Gravesend.
,, 3, 4.	*M. cervicornis.*	Zone of *B. mucronata*, Portsdown.
,, 5, 7, 8.	*M. Sparksi.*	Zone of *A. quadratus*, Portsdown.
Fig. 6.	,,	Zone of *A. quadratus*, Hensting, Hants.
,, 9.	*M. plicatella.*	Trimingham.
Figs. 10, 11.	*M. ædificata.*	Trimingham.

III.—On *Lanieria*, Duncan, a remarkable genus of the Holectypoida; with a preliminary note on the tendencies of Echinoid Evolution.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

Contents.

1. Historical.

Some time after the year 1850 d'Orbigny recognized, among a collection of fossils from Cuba, a species that he referred to the genus *Galerites* under the name of *G. lanieri.* The description and figures of the species were to have been included in vol. viii of the *Historia fisica, politica y natural de la isla de Cuba*, but the part of that work that should have contained them seems not to have been published.

It was not until 1881 that Cotteau ("Description des Echinides fossiles de Cuba," Mém. Soc. géol. Belg., vol. ix, p. 11, pl. i, figs. 7–13) gave a description of the form.* He used d'Orbigny's specific name of *lanieri*, and, with hesitation, included it in the genus *Echinoconus*, as the *Galerites* of previous authors was then called. As Cotteau himself remarked, the name of the fossil must be ascribed to him, as d'Orbigny's description was unpublished.

In 1897 Egozcue y Ciá gave a Spanish translation of Cotteau's description (Bol. Com. Map. geol., Madrid, No. 22, p. 9), giving a reproduction of the figures, and adding further measurements and a new locality for the species.

Duncan, in the *Revision* (1889), p. 168, very properly removed the species from *Echinoconus* and diagnosed a new genus, *Lanieria*, for its reception. It was, and is still, the sole species of the genus.

Cotteau, in the original description of the species, made use of several specimens (not all of which, unfortunately, belonged to the same genus), and gave figures of two. One of the figured specimens (Cotteau, loc. cit., pl. i, fig. 11), was in the Dewalque Collection, and is now in the British Museum of Natural History. In view of the confusion of forms described hereafter I hereby select this specimen (E. 4570) as the holotype.

There are five other specimens from the same locality and collection in the Museum. All of these were labelled "*Echinoconus lanieri*", and among them all the main features of Cotteau's description are included. However, only two of them (besides the type) belong to the genus *Lanieria*, the others being certainly referable to *Cænholectypus*. It becomes necessary, therefore, to distinguish between the two types represented, and to free the diagnosis of *Lanieria* from the characters of *Cænholectypus* with which it is encumbered. At the same time some further details of the structure of *Lanieria* can be given. The peculiar features of the genus raise a question of phylogenetic and morphological interest. I am preparing a more detailed study of this question as it affects the Irregular Echinoids, but the lines of argument are briefly put forward at the close of this paper.

2. Redescription of *Lanieria lanieri* (Cotteau), Duncan.

The three specimens of this species in the British Museum are registered as E. 4570 (the lectotype), E. 4571, and E. 4572. In the following description the first part is concerned solely with the type, additional features seen in the other specimens being added later. All the specimens are from the (?) Uppermost Cretaceous, Cienfuegos, Cuba.

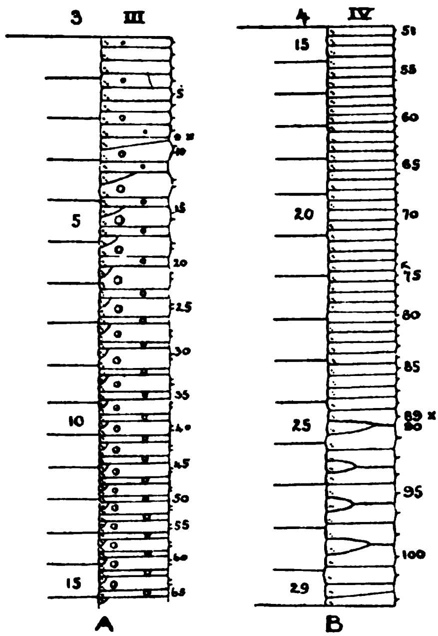
E. 4570. Diameter 15·9, height 14·2 mm. at ambitus. Ambulacra 3, interambulacra 7 mm. wide. Diameter of peristome 4·8, of periproct 3·9 and 2·2 mm.; distance between peristome and periproct 1·8 mm. Diameter of apical system 0·8 mm.

The *ambitus* is practically circular, and is situated about halfway between the apex and the peristome. The form of the test is almost globular, there being no appreciable flattening of the adoral surface. In fact, the specimen rests on the actual margin of the peristome, and on that alone, when placed with the adoral surface downwards. The test is very thin.

The *apical system* is central, approximately circular in outline, and projects slightly above the surrounding coronal plates. The sutures between the plates are not very clear, but suffice to show that there are five large genital plates, each perforated by a large pore, and five small ocular plates minutely perforated. The madreporite is broken, but was central and apparently prominent, restricted, as usual, to the right anterior genital. The whole apical system is typically that of a *Cœnholectypus*.

The *periproct* is oval, and, although below the ambitus, is situated well up on the test, being inclined at an angle of about 45° from the horizontal. The outline is sharply pointed at both the adoral and adapical ends, the latter being slightly the more acute.

The *peristome* is small (compared with that of the Holectypinæ) and apparently quite circular. No indication of branchial slits can be seen, but the margin of the aperture is not very clearly exposed.



A. Diagram of adapical part of amb. iii of *Lanieria lanieri* [B.M. E. 4572].
B. Diagram of adoral part (not quite reaching to peristome) of amb. iv of *Cœnholectypus cubæ* [B.M. E. 11516].
The numbers refer to plates, counted from the ocular margin.

The *ambulacra* are straight and narrow. The pores of each pore-pair are slightly inclined perradially and adorally. Towards the peristome the pore-pairs become triserial in arrangement, but they seem to recover something of their uniserial plan when quite near the peristome margin. There are about four ambulacral plates to each interambulacral on the adapical surface, and apparently throughout. Only eight or nine primary ambulacrals intervene between the oculars and the 'crushing-point', and the full degree of crushing is rapidly attained. The arrangement of the plates is similar in many respects to that found in *Conulus*. Of the three elements of a triad the adapical one is a narrow primary with parallel margins, the median one is an extremely minute demiplate (hardly extending perradially beyond the inner pore of its pair), and the adoral one is large, about twice the height of the adapical one. The perradial suture is zigzag for the length of about twenty plates from the apex, and then becomes almost straight. The main series of tubercles is situated on the large plates, near their adradial margins, and is persistent from apex to peristome. The second series is on the narrow plates, almost median, but becoming nearer to the perradial margin, and is persistent through most of the area. Both series of tubercles are of about the same size and are similar to those of the interambulacra.

The *interambulacra* are a little more than twice the width of the ambulacra. They are composed of about twenty-seven plates per column. The interradial suture is zigzag above, but becomes almost straight at and below the ambitus. The main tubercle series is not separable, in point of size, from the others. It is median on the adapical plates, but keeps at an almost uniform distance from the adradial suture throughout the column, thus appearing to pass down the outside of the area. The subsidiary tubercles that are between the two main series of an area are horizontally arranged, three or four on each plate near the ambitus. Those towards the ambulacra are in zigzag order—the principle of tuberculation being typically that of the Discoidiidæ. The surface between the tubercles is granulate. The test is somewhat worn adapically, but below the tubercles are seen to be in deep scrobicules.

E. 4571. A very large, crushed specimen. Diameter about 23, height about 21·5 mm. The ambulacra seem to have been slightly projecting above the interambulacra. The madreporite is very prominent.

E. 4572. A small specimen with an obscurely pentagonal outline. Diameter 13·6, height 11·2 mm. The periproct is broken, and the surface of the test weathered. The sutures are very clear, but surface ornament is largely missing. Genital 4 seems to be without a pore, but this is probably due to either abnormality or bad preservation. The ambulacra are well shown adapically, and part of the anterior area is diagrammatically shown in Fig. A. The sutures are obscure below the ambitus. There are about twenty-five interambulacral plates per column. Ten plates adapically, and about five adorally, are fairly high, but the middle region is composed of plates of considerably less height.

3. Description of *Cœnholectypus cubæ*, n.sp.

The other three specimens that were associated with *L. lanieri* (Nos. E. 4574, E. 11516, E. 11517) belong to a species of *Cœnholectypus*. The "individu subconique et à la face inférieure plane; hauteur 11 mm., diamètre 19 mm." of Cotteau (loc. cit., p. 11) undoubtedly belonged to the same species. The variety Cotteau described (which is probably founded on the specimen mentioned above) is certainly a *Cœnholectypus*. The "face supérieure légèrement conique", "face inférieure tout à fait plane", "pores ambulacraires . . . dans la région inframarginale . . . simples et directement superposées", are features exactly corresponding with those of the three specimens under consideration.

In one of them (E. 11516) the sutures are well shown, and the ambulacra are seen to consist of primaries from the apex to a point very near to the peristome. The first sign of 'plate-crushing' appears at No. 89 from the apex, while in *Lanieria* the corresponding point is about nine plates down. The diameter of this specimen is 18·5 mm., and its height 12·25 mm., and the periproct is only 1·4 mm. distant from the peristome.

The other two specimens seem to agree closely in all visible features with this one. No. E. 4574 is 18·5 mm. in diameter and 14·5 mm. high, while No. E. 11517 is smaller and less well-preserved. The form appears to be new, and I select No. E. 11516 as the holotype. The systematic summary of the species can be expressed as follows:—

CŒNHOLECTYPUS CUBÆ, n.sp.

SYN. *Echinoconus lanieri*, var., Cotteau, 1881, Mém. Soc. géol. Belg., ix, p. 11.

Horizon: ? Uppermost Cretaceous, Cienfuegos, Cuba.

Type: e coll. A. H. Lanier, in British Museum.

4. THE FAMILY LANIERIINÆ, NOV.

As will be seen from the description, the characters of *Lanieria* are anomalous and in some ways synthetic. The apical system and tuberculation are definitely like those of *Cœnholectypus*, while the general proportions of the test, and particularly the structure of the ambulacra, conform more to the type of *Conulus*. The two latter genera are strikingly different from each other, and are probably the results of an early separation in phylogeny. It is therefore unlikely that *Lanieria*, occurring in deposits of presumably Upper Cretaceous age, can represent a truly intermediate stage between them.

To my mind the characters of the apical system are less likely to be suddenly or irregularly modified than those of the ambulacra. The former structure is completely developed early in ontogeny, while the ambulacra are continually growing (in the Holectypoida) throughout life. It is therefore possible that some comparatively trifling change could cause 'plate-crushing' to appear in the ambulacra, whereas fundamental and complete modification would be necessary for the development of a fifth genital and gonad.

It seems likely, therefore, that *Lanieria* is a peculiarly specialized offshoot from the Discoidiidæ, and has no direct phylogenetic connexion with *Conulus*. In a recent paper (Proc. Zool. Soc., 1912, p. 450) I included *Lanieria* among the Holectypinæ (by error as a sub-genus of *Holectypus* on p. 477), but had not then seen a specimen. In view of the remarkable ambulacral features, it seems best to place it in a separate sub-family of the Discoidiidæ, which may be called the Lanieriinæ.

Another genus, *Discholectypus*, Pomel, which I regarded as "*incertæ sedis*" in the paper above referred to, can join *Lanieria* in this sub-family. *Discholectypus*, whose type is *Holectypus meslei*, Cott., Peron, and Gauth., from the Lower Cretaceous of Algeria, resembles *Lanieria* in its ambulacral complexity, and is otherwise closely similar to *Cœnholectypus*. I have not seen a specimen, but the figure given by Cotteau, Peron, and Gauthier (*Ech. foss. Algérie*) shows the ambulacra to be even more like those of *Conulus* than are those of *Lanieria*. The adapical member of each triad, instead of being a thin lath with parallel edges (as in *Lanieria*) is wedge-shaped, being pinched at its perradial end.

The systematic position of these two genera may be summarized as follows:—

HOLECTYPOIDA. DISCOIDIIDÆ.
LANIERIINÆ.

Two genera. *Lanieria*, Duncan. *L. lanieri*, type.
Discholectypus, Pomel. *D. meslei*, type.

5. THE BIOLOGICAL SIGNIFICANCE OF THE LANIERIINÆ.

Assuming that the foregoing systematic association of the Lanieriinæ with the Discoidiidæ is correct, an interesting feature in morphogenesis is presented. The peculiar ambulacral structure of *Conulus* (which is continued, probably by direct descent, in *Echinoneus* and *Micropetalon*), although obviously connected with the usual structure of the Holectypoida, is so definite that it would be thought to be a special development not likely to be repeated independently.

Excluding *Amblypygus* from the discussion (for this genus may possibly be an Echinoneid, though apparently closely related to the Echinolampidæ), we find that '*Conulus* structure' has appeared three times in the history of the Holectypoida. In one case, *Discholectypus*, the ambulacral complexity is unaccompanied by any other similarity to the *Conulus* type, while in *Lanieria* the general facies of the test (although no other detail of structure) conforms to that of *Conulus*. It seems impossible that *Discholectypus* and *Lanieria* can be in direct phylogenetic sequence, taking into consideration their distant and restricted localities and widely separate horizons. Further, the nature of the ambulacral plating does not, in this case, seem at all to be connected with any adaptive purpose. Except, perhaps, near the peristome, there is no actual increase in the number of plates (i.e. podia) achieved by the 'plate-crushing'.

In the independent development of this peculiar structure in at least three distinct types of the Holectypoida we seem to find an expression of some fundamental tendency in evolution which, within the limits of an order, can cause one set of structures to be developed, without regard to the others, on a definite plan. It may be suggested that there is an objective, or goal, towards which the evolution of a group is tending, and which may be reached independently, and piecemeal, by various members of the ramifying series of the group.

Expressing this phenomenon in somewhat 'diagrammatic' language, one may suggest that at the inception of an order the first member is a complex association of parts in definite stages of development; and for each part there is a certain ideal line of evolution along which, as far as possible, it will travel independently towards a certain limit. The succeeding members of the order will be composed of the same parts as their progenitor, but these parts will be in diverse stages of evolution, some having progressed rapidly, others slowly, some having remained stationary, and others having been retrogressive.

Acceleration and retardation become, then, as important factors in phylogeny as they are recognized to be in ontogeny, and, as in the latter case, concern the separate parts of the individual rather than the complete organism.

To sum up, the true phylogenetic position of a genus (or any other rank) can be expressed only after its features have been separately analysed and their various stages of progress appreciated. The conception can be made clearer by thus expressing (for a few characters) the relative positions of *Lanieria*, *Discholectypus*, and *Conulus*.

Structure.	Ambital Outline.	Apical System.	Ambulacra.	Interambulacral Ornament.
Trend of evolution in Echinoidea Irregularia.	Circular→ Cordiform.	Broken→ Restored.	Simple→ Compound.	'*Pygaster*-like'→ Uniform, granular.
Lanieria . . .	R	A	A	Ra
Discholectypus . .	R	A	A	Ra
Conulus . . .	Ra	rA	A	rA

R = retarded evolution. A = accelerated evolution.
Ra = retarded, but slight progress. rA = progress, but not complete.

In tracing the condition of phylogenetic development of a group it is necessary, then, to have regard to three points: (1) an analysis of the individual and a 'diagnosis' of each separate structure; (2) a knowledge of the corresponding features of the original member of the group (sometimes available, often partly hypothetical); and (3) a knowledge of the ultimate possibilities of each structure in the course of its evolution (hypothetical, but to be roughly ascertained by considering the most highly developed conditions found in the group). Care must, of course, be taken to eliminate, as far as possible, conditions which are the direct results of adaptation to environment.

IV.—The Upper Trias of Leicestershire.

By A. R. Horwood.

(*Continued from the March Number, p. 121.*)

(5) *The Rhætic Outcrop.*

Although the Rhætic beds are not exposed continuously along the eastern boundary of the Keuper outcrop, they have been proved at many points from the River Trent in the north on the

Nottinghamshire border to Glen Parva in the south. South of this point there is so much drift, and borings within the Liassic outcrop have been so isolated or shallow, that there is a gap in our knowledge of the intervening ground between the last point and the Rugby district. The Countesthorpe boring, carried to a depth of over 600 feet, encountered Upper Keuper beneath the Drift, with no intervening Rhætics. Commencing in the north in the Gotham district the two outliers are capped above the Red Marl and Tea-green Marl with Rhætic beds, and Lower Lias Limestone (*Ps. planorbe* zone) above. At Ash Spinney at the south end of the southern outlier, and at the east end of Crownend Wood, Black Shales with *Avicula contorta* crop out; and on the west side septaria are seen. On the north-west side of the northern outlier at Cottager's Hill *Protocardium phillipianum* has been found in a well-section near the lane. Rhætic shales are seen in the shafts driven for gypsum works about Gotham. To the south, at East Leake, in the railway cutting through Normanton Hills at the south end of the tunnel, there was formerly a good section showing Lower Lias and Rhætics faulted against New Red Marl, with a very sharp line of division, a continuation of the Hoton fault, which is extended in a north-west direction to Castle Donnington, between which two points the Soar Valley obscures it; but it cuts off the Lower Keuper at Hemington, bringing the Red Marl to the surface.

A section measured opposite the fault where the beds became more horizontal showed:—

		ft.	in.
Lower Lias (*Planorbis* zone).	Stone	0	2
	Shales	0	1
	Stone	0	9
	Shales	1	7
	Stone	0	9
	Shales	2	4
	Stone	0	5
	Shales	1	6
	Stone	0	6½
	Shales	0	1
	Stone	0	2
	Shales	0	1½
	Stone	0	2
	Shales	0	2½
	Stone	0	0½
	Fissile pyritic stone, parted by way-boards of shale (¼ inch), partly conjoined with the next	0	4
	Shales	0	2
	Stone with *Ostrea liassica*	0	4½
	Shales below nodular limestone	0	5
	Shale	0	9
	Nodular limestone	0	9
	Upper Rhætic shales	9	0
	Nodular limestone	1	0
	Lower Rhætic shales	24	0
	Tea-green Marl	16	6
		62	2½

In a section Browne drew up for the Ipswich meeting of the British Association he gives the following section:—

	ft.	in.
Upper Rhætic shales	7–12	0
Limestone	0	6
Lower Rhætic shales, dark-grey . .	12	0
Lower Rhætic shales, rusty-black (*Isodonta*, *Myophoria*)	2	0
Sandstone, pyritous	0	1
Shales, black	1	3
Shales, black, hard band	1	0
Thickly laminated shales . . .	5	0
Sandstone, with galena, pyritous . .	0	2
Black shale	1	2
Upper Keuper Tea-green Marls . .	16	6
	51	8

A section on the west side, north end, showed Red Marl on one side of the fault with two skerries below a thick bedded sandstone above. Tea-green Marls are shown squeezed in between this, and the Rhætic and Lias. Another section showed Lias with two beds of limestone at the Loughborough or south end of the tunnel, rising to the north above Upper Rhætics with a band of White Hur below, and Lower Rhætic beneath it.

An interesting suite of fossils was obtained here (see Palæontology). Mr. W. T. Tucker found a piece of bone-bed, 2 inches thick, "stuffed full of bones, scales, and similar to the Aust breccia." About 10 feet above the Tea-green Marls a fish-band was found, also coprolites, vertebræ, and teeth. He also noticed a nodular band 30 feet below the first Lias grey nodular band, with 20 feet black shales beneath it. If so, the Rhætics here were 50 feet thick.

At the junction between the Tea-green Marls and the black shales there was a yellow band, but no regular bone-bed. The Tea-green Marls showed traces of erosion. At the north end of the tunnel the dip was 6° to the south. At the south end it was 2°–6°.

To the east at Costock at Flint Farm in the stream section flinty limestone is exposed, and some pits about here were formerly worked for limestone. To the south at Rempstone flinty limestone occurs at Sutcliffe Hill, and where the outcrop crosses King's Brook. The Stanford fault shifts the outcrop again to the west, and about Stanford Hall in the trough high ground is probably formed by these beds. Between Walton and Barrow, in the valleys cut through the Drift and Lower Lias, the Rhætics have been exposed on each side of the brook, and the outcrop is continuous between here and Walton, black shales being struck in a well 500 yards west-south-west of Walton Church. The outcrop continues westward from here to Barrow Hill.

H. B. Woodward[1] recorded the occurrence of Rhætics at Barrow-on-Soar, and remarked that "above the black shales there was a considerable thickness of apparently unfossiliferous grey earthy

[1] Ansted (1866) noted them earlier.

marl, capped by a hard bed which I took to represent the upper limit of the Rhætic formation. Above it the ordinary Lower Lias limestones and clays come on".

Laminated lumpy shales overlying Tea-green Marls have been exposed in the Midland Railway cutting 600 yards north-west of the station. South of Barrow at Netherfield grey shale and nodular limestone was found with a dip of 12°, accentuated by the Barrow and Sileby fault. At Barrow Hill black shales and a bone-bed overlaid Tea-green Marl.

To the south, in the Wreake Valley, Lias comes on directly against Red Marl owing to the Sileby and Barrow fault, which causes a displacement of the beds to the west, and in a well-sinking at Ratcliffe Boulder-clay (80 feet) rests on Red Marl, showing they are absent here. The lowest beds of the Lower Lias are seen to the east at Kirby Bellairs, so that the fault runs north of the Wreake Valley.

In the boring for water at Melton Rhætic black shales and a nodular limestone 16 ft. 4 in. thick rest on 247 ft. 10 in. of Red Marl, with sandstone near the base, and gypsum beds.

At Brooksby Red and Grey Marls are found up the Wreake Valley, indicating the extension of the Rhætics so far east. In the stream-side between Queniborough and Gaddesby Grey Marls and mottled clays are exposed, and further south near the village east of the new hall Grey Marls are seen along the slopes. In the brook at Barkby and half a mile from the village Grey Marls are also exposed, as well as in fields. At the New York Farm on the Ridgemere road, black shales were met with for 52 yards. Paper shales have been exposed on the ridge north of the fault at Barkbythorpe, which makes a bold escarpment.

At Humberstone the Rhætic beds have been exposed at various points and pierced by borings and well-sections to the east of the Spinney Hills in the low ground between the latter and Crown Hills from Evington Road to Uppingham Road. The shales were struck in the boring at Lodge Farm (2) and appear in the other adjacent or Crown Hill borings (16 ft. 9 in.), but were absent in the Willow Brook boring. They crop out in the Humberstone drive, where Lower Lias beds succeed them. The well-boring at the Asylum pierced Lias and 20 ft. of Rhætics with nodular limestone. The nodular septaria were recently met with in a well in Freeman's Road North below river gravels, and the slopes at the junction of Green Lane and Coleman Road are in Rhætic shales.

At the top of the Gipsy Lane Pit, on the east side, thin bands of black shales succeed a thick section of Tea-green Marl. At their junction I found ***Estheria minuta***. In a small pond in a field to the east they are again exposed. Following the hillside they run in a north-east direction to a point just north of the Humber Stone, where in a ditch the line of fault brings the Red Marls against the black shales in the second field on the Humberstone and Barkbythorpe bridle-road.

In an excavation for St. Philip's Church 2 feet of Rhætic shales were encountered beneath 9 feet of soil and drift. In Green

Lane Road 2 feet of shales were found in a well-section under 8 feet of soil and drift, and they outcrop in the ditch on the west side.

There has been some discrepancy as to who first discovered the Rhætic beds at Leicester. Mr. J. J. H. Teall, F.R.S., reported their occurrence here in 1874, but they were not then actually recorded. Later on Mr. W. J. Harrison described them in 1876 in the Report of the Geological Section to the Leicester Literary and Philosophical Society.

The section of Rhætics at the Spinney Hills, now built over, was described by W. J. Harrison in 1876. Then three brick-pits were situated on this ridge, which forms the Rhætic escarpment between Humberstone Road and Victoria Park. The valley between has been excavated, and only the Tea-green Marls are visible, but eastward the Rhætics come on again. The floor of the pits was in Red and Blue Keuper Marl (10 feet) with selenite and salt pseudomorphs. He notes the diminished thickness of the red bands at the top of the Keuper. There are about 16 feet of Tea-green Marls below the Rhætics here, which are black shales about 10 feet thick. The higher beds with a second nodular limestone were noticed in other excavations.

The section here (Moore's Pit, junction of Wood Hill and Prospect Hill) was:—

		ft.	in.
	Soil and drift, with flint implements and Roman pottery, etc.	1	0
Lower Rhætic.	Nodular band of limestone, with casts of *Estheria*, *Avicula contorta*	0	6
	Light-coloured shales, with sandy partings, *Modiola minima*, *Avicula contorta*, *Cardium rhæticum*	4	0
	Dark shales, with sandy partings, *Ophiolepis damesii*, *Pholidophorus mottiana* (= *higginsi*)	1	0
	Finely laminated black shales, *Avicula contorta*, *Cardium rhæticum*	2	0
	Sandstone = *Axinus* bed, worm-tracks	0	1
	Black shales, coarsely laminated	2	6
	Bone-bed, *Gyrolepis*, *Saurichthys apicalis*, *Hybodus minor*, *Ceratodus*, *Nemacanthus monilifer*, *Ichthyosaurus*, *Plesiosaurus*, *Sargodon tomicus*, etc.	0	3
Upper Keuper.	Light-buff sandy shales with hard courses, bluish nodules on lower part, fish scales	16	0
	Red and Blue Upper Keuper Marl	10	0
		37	4

The upper surface of the Red Marl was uneven, hollowed out in long curves. The dip was south-east. The Tea-green Marl was green in parts, with blue nodules in the lower part, fissured, and with conchoidal fracture. Selenite occurs in it, and pseudomorphs of salt crystals, as well as ripple-marks. Fish-scales are numerous. I have examined these, and they are of the Semionotoid type. In the same material *Estheria minuta* is abundant. Teeth also occur. Mr. Harrison said he found a single insect wing here, but I think this must have been *Estheria*, as he said it perished on exposure, a feature common to *Estheria*. The upper surface was uneven.

Rain pittings were abundant. In the unweathered state the bone-bed is hard, but the contents brittle. Harrison obtained from here large vertebræ of *Ichthyosaurus*, rib bones belonging to *Plesiosaurus* (one 18 inches), and Labyrinthodont bones, worn and rolled bones, coprolites containing small quartz pebbles and bits of Dane Hill Sandstone. Pebbles are mainly quartzose or of slate, and rounded; some 3–4 inches, of local origin. *Isodonta* occurs loose in the bone-bed. The Pullastra Sandstone is reddish, and ½–1 inch thick.

The first British example of *Ophiolepis damesii* was found here, but others have recently been found elsewhere. It is probably dimorphic, with a large and small form. Recently fine large types have been found at Glen Parva, as well as the smaller type. Both were regarded by Wright as belonging to this species. Kaolinite, bitumen, selenite, and mica are common in the dark shales with sandy partings. In the nodular limestone the *Estheria* occurred with *Avicula* on the outside. Harrison says a second bed occurs 2 feet above the last, and light-coloured clay and sand above, as seen in the section described by Bates & Hodges. He mentions the occurrence of Rhætics in an exposure on the Great Northern Railway near Crown Hill, where beds of limestone ('Firestones' and 'guineas' of Warwickshire), and a thick bed, probably true White Lias, are said to have been met with. He also states that on the Leicester and Wigston line a section showed the Rhætics had been eroded.

Mr. Browne, in his detailed *History of the Geology of the Borough of Leicester*, gives a most valuable series of sections in the Spinney Hill district, where Rhætic beds were formerly met with. It is unnecessary to discuss these further here, especially as the whole district is now entirely built over.

Messrs. Bates & Hodges gave an account of a section from Diseworth Street to St. Peter's Road in which Lower Lias and Upper Rhætics were exposed, showing 11 ft. 1 in. of the latter with *Isodonta ewaldi*. Other sections in the district show that the Rhætics of the Spinney Hills were thinner than at Wigston. There is here no trace of White Lias, and in all essential characters the Leicester exposures closely resemble the beds at Glen Parva, where again Upper Rhætic is followed by Lower Lias without any intervening White Lias.

From the Spinney Hills the Rhætic beds are continuous across Victoria Park to Clarendon Park and thence to Knighton village, where the Upper and Lower Rhætics have been exposed in shallow sections near the church and in the lane. The black shales also are seen in the valley at the surface, and form a fairly wide outcrop above Tea-green Marls. Southward recent sewer excavations between here and Little Wigston have exposed the lowest beds of the Lower Lias and Rhætic Shales. They have also been found to underlie Liassic beds at Gold Hill Farm, whence the outcrop is obscured by Drift, so that in the Midland Railway cutting they are not exposed at the bridge. From this point, close to the Wigston and Aylestone Road, it turns due west, till just east of Aylestone Grange, where, still obscured by Drift, it strikes due south to the Glen Parva Barracks, where it again turns to the east and is exposed at the station, a fine section (80 feet) from Keuper to Drift, including Lower Lias, having been excavated for brickmaking. The shales are seen in the railway embankments to the north-east at the base.

Messrs. Wilson & Quilter[1] were the first to describe this section in detail, and this summarized was as follows:—

	ft.	in.	
Boulder-clay	8	0	(to 27 feet).
Lower Lias	1	0	
Upper Rhætics (called White Lias) . .	22	5	
Lower Rhætics	17	10	
Tea-green Marl	15	5	
Red Marl	14	6	
	79	2	(to 98 ft. 2 in.)

They note the fact that there is no true bone-bed, but an evanescent seam of white sand, with scattered teeth, coprolites, etc. From the Lower Rhætics they record *Isodonta ewaldi*, *Protocardium philippianum*, *Avicula contorta*, *Gyrolepis*, *Acrodus minimus*, *Hybodus minor*, *Saurichthys*, *Nemacanthus*. They found the cast of a single ray of *Ophiolepis damesii*, but not in situ. They report fish-remains at a definite horizon, 3 ft. 6 in. to 3 ft. 9 in. above the bone-bed. They found the junction between the Tea-green Marl and Black Shales sharp, but the beds conformable. The former are referred to the Keuper, into the Red Marls of which they imperceptibly graduate. The Lower Lias in a smaller pit was found to consist of 1 ft. 9 in. of flaggy limestones and shales, and above 7 feet of laminated blue shales. The dip was two degrees to the north-west. The existence of a small fault[2] was noticed.

In a later paper Quilter speaks of the Tea-green Marls as eroded at the top. The *Gyrolepis* is referred to *G. tenuistriatus* (= *G. albertii*), and the *Saurichthys* to *S. apicalis* (= *S. acuminatus*). *Pecten valoniensis* is added to the list of fossils in the Black Shales. The yellow blue-hearted nodular limestone at the top is regarded as equivalent to the "sun-bed". In a later paper the same writer adds *Pholidophorus nitidus* to the list of fossils in the Black Shales, and appends a list of fossils found in the Rhætics of Leicestershire, including those found by Harrison, adding *Plicatula intustriata*.

Dr. A. S. Woodward examined some fish-remains obtained by Mr. A. E. Baker from the Spinney Hills, which included *Hybodus minor*, *H. cloacinus* (new to Britain), *Acrodus minimus*, *Nemacanthus*, *Sphenonchus*, *Gyrolepis albertii*, *Sargodon*, *Saurichthys acuminatus*, and *Ceratodus latissimus*. Some fish from Wigston obtained by Wilson are assigned to *Pholidophorus nitidus* (a small form of *P. higginsi*). This was obtained in cores from the Evington boring with *Avicula contorta*, etc.

In 1891 M. Browne, from material in the Baker Collection from Spinney Hill, identified *Ctenoptychius ordii* as the worn basis of

[1] J. Plant (1866) noticed the occurrence of Rhætic beds on the Leicester and Nuneaton line in 1863.

[2] A similar fault is shown in the section at Diseworth Street, east of Spinney Hills.

a tooth of ***Hybodus minor***, and ***Sphenonchus*** as belonging to the same. He suggested ***Sargodon tomicus*** resembled shed tubercles of fin spines of ***Nemacanthus monilifer*** (=***Hybodus minor***).

The next description of this section was by M. Browne (1901). He remarks that the Lower Rhætic upper limit is generally taken as the second limestone (from below), but he prefers to take the first one or just above it as the junction with the Upper Rhætics. He suggests that at 2 ft. 8 in. a rust-coloured band may represent a second bone-bed, as at Aust. Above this the beds are more fissile, crowded with ***Isodonta***. The first limestone band, he says, is 90 per cent carbonate of lime, but this is an over-estimate, as it is largely detrital in origin. The Upper Rhætics contain only Annelid burrows above the second limestone, which is said to contain ***Estheria minuta***. A curious statement is made to the effect that a persistent band of limestone nodules above the second thick nodular bed "ends the true Rhætic". The occurrence of radiating gypsum is noted for the first time. The yellowish limestone is said to be Lower Lias above, "Sub-Lias = White Lias" below. ***Colobodus***, described at the Brit. Assoc., 1891, is recorded from the bone-bed. He remarks that both Tea-green and Red Marl might reveal traces of fish-scales, and teeth of sharks in the sandstone and skerries. He notes that the Tea-green Marls are 20 feet, not 15 ft. 5 in. as given by Quilter. He correlates the Sub-Lias with the ***Ostrea*** zone, and this obviously with the White Lias. He says the compound rock was 3 feet in the north-east part of the pit, and at the top contained Liassic fossils. He also says the limestone resembles Cotham Marble and White Hurs of Barrow-on-Soar, and that nodules in the lower part may be the White Hurs=in part the "Cotham Marble"; and probably that the Fourfoot Lower Lias Limestone "is represented at the top of the thick stone". To the south the Ironstone of Barrow-on-Soar is interstratified with this "compound rock", which occurs at the base of the Fourfoot Limestone. He notes that the Fourfoot or good-for-nothing Limestone occurs in the pit to the south-west curiously pitted with raindrops or Lithodomi, and contains ***Ps. planorbe***. Unlike Wilson and Quilter, he does not confound the Upper Rhætics and White Lias, but regards beds above his Upper Rhætics as "Sub-Lias". L. Richardson later redescribed this section, with critical notes on the above correlations. At the time, I must say, I agreed with the main portions of his description and measurements, but having had occasion to remeasure the section, I find that my own are slightly different. Richardson draws the line between the Upper and Lower Rhætics at 10 ft. 7 in. from the top of the former, relying on the unfossiliferous nature of the Upper and the yellow colour of the shales as distinctive features for separating them from the Lower. The bottom part of the compound bed forms the top of the Rhætics, and the Upper the base of the Lower Lias if not divided by marls. He considers there is a non-sequence between them, as between the Tea-green Marls and the bone-bed, since elsewhere Sully Beds intervene, though here the two are conformable. He estimates the Tea-green Marls at 12–15 feet, but I find the estimate of 20 feet given by Browne more correct. He says "now it is at, or may be a few inches below, this limestone bed that I would draw the line between the Lower and Upper Rhætic", that is, the second limestone band. But in the section the line is drawn 9 ft. 3 in. above this bed. He reiterates the statement that the Lower Rhætics here are characterized by absence of hard bands. My own examination resulted in the discovery of several hard but thin beds of gritty or pyritic sandstone. The Upper Limestone is compared by Richardson to bed 9 at Langport and elsewhere. He thinks the *Ophiolepis damesii* bed should be 2–3 feet below the Lower Rhætic bed. There are two horizons for it at Wigston, as will be seen. He does not credit the record of *Estheria* in these limestone beds by Browne, but it must be remembered Harrison found them on the outside of the same beds. He draws attention to the wrong correlation between the *Ostrea* bed and the White Lias. If the lower part of the compound bed is equivalent to Cotham Marble, then the top is the *Ostrea* bed, Insect and Crustacean bed or White Lias of Mid-Somerset, but he thinks the compound bed is equivalent to the *Pseudomonotis* bed of Garden Cliff.

My own examination of the pit is summarized in the following section. The palæontology is dealt with elsewhere. Messrs. A. J. S. Cannon and Siddons have made important discoveries here, some of which have already been described, whilst others are reserved for the conclusion of this paper.

		ft.	in.	
Lower Lias (*Ps. planorbe* zone).	1. Drift, sand, and gravel . . .	6	0	(to 2 ft. 3 in.)
	2. Laminated dark shales, weathering grey, with a blue line near the top, iron-stained, weathering light brown	1	0	(to 1 ft. 2½ in.)
	3. Dark-greyish blue-centred limestone, flaggy above, and below massive in the centre; crushed crystalline limestone, in thickest part, compound, consisting of dark-blue and light-grey variegations, false-bedded, dipping south. At the top in the deepest part resembling blue-hearted nodular beds, layer 1 inch thick, bored by vertical worm-tubes (cf. Browne)	0	4½	(to 1 ft. 2 in.)
	4. Stiff yellowish-brown nodular marl with ironstone streaks, coated with manganese . . .	0	5	(to 1 ft. 4 in.)
Upper Rhætic.	5. Blue-hearted nodular limestone, with veins of calcite 5 inches, continuous in places, elsewhere broken. In part double, with a marly layer between . .	0	5	(to 1 ft. 0½ in.)
	6. Brownish nodular marl . . .	0	8½	
	7. Blue nodular limestone, with iron-stained band at base . . .	0	1	
	8. Blue laminated shales, with a band of pyritic nodules at the base, and 5 feet above the base a rust band	11	0	
	Carried forward . .	20	0	

			ft.	in.	
		Brought forward . .	20	0	
	9.	Bluish laminated shales, with two rust bands 6 inches, and 2 feet below the last, with a hard thin indurated band (½ inch) 6 inches above the base, and a thicker band (¾ inch) at the base, with fine selenite crystals . . .	4	0	
	10.	Bluish laminated shales, with sandy partings	6	0	
	11.	Thin septariform band, irregular, with so-called sandy parting, which here is rotten septaria, and thin bluish shale below .	1	0	
	12.	Very finely laminated shales, and band of nodular limestone at the base	1	0	
	13.	Finely laminated blue shales .	2	0	(to 3 ft. 4 in.)
Lower Rhætic (*Avicula contorta* zone).	14.	Thick uniform band of septariform nodular limestone . . .	0	5	
	15.	Thickly laminated earthy grey-blue shales, with a band of sandstone (¾ inch) at the base, and three or four sandy partings . . .	1	9	
	16.	Grey-blue thickly laminated clay, with pyritic bands (¼ inch) at the base	2	0	
	17.	Bluish - grey thickly laminated shales, with thin pyritic nodular bands, commencement of septariform nodules . . .	2	8	
	18.	Shales similar to 17 . . .	4	9	
	19.	Nodular band	0	3	
	20.	Thickly laminated blackish shales, with line of thin gritty sandstone at base (*Isodonta* bed) . .	2	1	
	21.	Similar to 20, with rust band at base, but more fissile and sandy	1	7	
	22.	Thinly laminated fissile paper shales, with numerous fossils .	2	10	
	23.	Bone-bed	0	1	
	24.	Tea-green Marls, with eight nodular bands and fish horizon 3–4 feet from the base, another 1 foot from the base, or with basal line of fish-scales, worm burrows 2 feet from top, *Orbiculoidea Townsendi* 5 feet from top .	20	8	
	25.	Pink marl	0	8	
	26.	Green marl, with fish-scales .	0	5	
	27.	Red nodular band	1	9	
	28.	Pinkish-green nodular marl . .	0	4½	(to 5 inches)
	29.	Red or pink marl merging into 30	0	6	(to 1 foot)
	30.	Greenish-pink or purple marl .	0	6	(to 8 inches)
	31.	Pinkish-purple marl . . .	0	8	
	32.	Green marl	0	3	(to 4 inches)
	33.	Red marl	1	0	
	34.	Gypsum	0	6	
			79	8½	(to 101 ft. 9 in.)

It will thus be seen that the different beds examined in detail are far from being so uniform as is generally assumed. The total thickness has also been under-estimated.

Reference has been made to the Crown Hill boring, where 16 ft. 9 in. Rhætic beds, including Tea-green Marl, are said to have been met with. The base is given as at 205 ft. 10 in., and the top at 189 ft. 1 in. But cores at 163 feet are apparently in Rhætics, and the junction with Lower Rhætic occurs probably at 176 ft. 10 in., and at 182 ft. 1 in. the beds are black and contain *Avicula contorta* and *Pecten valoniensis* between this and 187 ft. 3 in. A core marked 174 ft. 0½ in. contains the latter also. The Tea-green Marl, in fact, commences at 189 ft. 10 in. and continues to 202 ft. 9 in. There are thus 39 ft. 9 in. of Rhætic and Tea-green Marl, and 26 feet of Rhætic. *Gyrolepis* scales occur at 192 feet in Tea-green Marl. *Pholidophorus higginsi* was obtained in the Black Shales.

In a boring at Billesdon near the brook below Frisby, beds between 648 and 716 feet are probably in Rhætics, *Avicula contorta* occurring in the last 5 feet, above 15 feet of Tea-green Marl and 238 feet of marly sandstone with thin gypsum beds. If these thicknesses are correct the beds are thicker between Melton and Leicester, and as well developed as at Newark.

(*To be continued later on.*)

V.—On the Discovery of Fossil Plants in the Old Hill Marls of the South Staffordshire Coal-field.

By E. A. Newell Arber, M.A., Sc.D., F.G.S.

It is unfortunately true that our present knowledge of the fossil flora of the South Staffordshire Coal-field is lamentable, considering its size and importance and the abundance of fossils which it is known to contain. All that has been recorded from this coal-field is contained in a single paper by Dr. Kidston,[1] published twenty-five years ago, on the fossil plants of the Hamstead boring, with the addition more recently of a scanty list of fossils from the Langley Green boring,[2] and some other special studies on certain particular fossils, such as *Crossotheca* and the fructification of *Neuropteris*. Prior to these records Hooker alone appears to have described plants from this coal-field.

I have been hoping for some years past to do something to remedy this sad state of affairs, and a beginning has been made. I am now able to announce that my friend Mr. Henry Kay, F.G.S., of Birmingham, has quite recently discovered a large number of well-preserved plant remains in the Old Hill Marls, or rather in beds of grey clay or clunch interbedded with the red marls. This important discovery, which is due to Mr. Kay's skilful and patient collecting, helps to fill a gap in our knowledge of the plant succession in this coal-field. The beds in question occupy a perfectly definite position in the Coal-measure sequence. These "Red Coal-measure Clays" of Jukes lie intermediate between the Productive Grey

[1] Kidston, Trans. Roy. Soc. Edinb., vol. xxxv, pt. vi, p. 317, 1888.
[2] Kidston, Summ. Prog. Geol. Surv. for 1905, p. 174, 1906.

Measures below and the Halesowen Sandstone group above. The locality from which Mr. Kay obtained the specimens, which he has kindly placed in my hands for description, is the Granville Clay Pit, at Old Hill.

In the present note I propose to indicate briefly some of the species represented, which I hope on a future occasion to describe more fully. They are very well preserved, as a rule.

The Equisetalean remains are not very numerous, and of these the specimens of the external surface of *Calamites ramosus*, Art., are the most interesting. *Annularia sphenophylloides* (Zenker) and *Calamocladus equisetiformis* (Schl.) also occur. The Sphenophyllales are represented by *Sphenophyllum cuneifolium* var. *saxifragæfolium* (Sternb.). The fern-like plants include a *Renaultia*, probably *R. Footneri* (Marrat), *Neuropteris flexuosa*, Brongn., and *N. tenuifolia* (Schl.). The Pecopterid types are varied, good specimens of *Pecopteris oreopteridia* (Schl.), as well as *P. Miltoni* (Art.) and *P.* (*Dactylotheca*) *plumosa* (Art.), occurring. A *Rhabdocarpus*, which may be compared with *R. sulcatus* (Presl), is also present.

The Lycopods are represented by *Sigillaria principis*, Weiss, *Lepidophloios acerosus* (L. & H.), and *Lepidostrobus variabilis*, L. & H. The most interesting fossil, however, is what I take to be a small specimen of the cone of *Sigillariostrobus nobilis*, Zeiller, which is the first record of this interesting species from Britain. I have also, curiously enough, obtained several undoubted examples of the same plant from the Wyre Forest Coal-field recently, and these I hope to describe before very long.

The known flora of the Old Hill Marls is too small at present to indicate the horizon of these beds beyond doubt. While many of the above species are most abundant in the Middle Coal-measures, the presence of *Pecopteris oreopteridia* (Schl.) and *Neuropteris flexuosa*, Brongn., species which have not been recorded below the Transition Series, indicate that the later is the probable horizon. The Old Hill Marls probably occupy a low position in the Transition Coal-measures. The known flora of this horizon in South Staffordshire at present consists of eight species, recorded by Dr. Kidston[1] from the Hamstead boring between 1,236 and 1,320 feet, and of these only the composite *Lepidostrobus variabilis*, L. & H., is also found in the Old Hill Marls.

REVIEWS.

I.—The Mesozoic Flora of Graham Land. By T. G. Halle. Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition, 1901–3. Bd. iii, Lieferung 14. Stockholm, 1913. Price 16*s*.

THE evidence that the existence of genial climates at the Poles has been the rule rather than the exception in the past is one of the most fascinating and noteworthy results of the study of fossil plants. The present memoir, none the less welcome because it appears in excellent English, is the most important contribution

[1] Kidston, Trans. Roy. Soc. Edinb., vol. xxxv, pt. vi, p. 319, 188 ; see als Quart. Journ. Geol. Soc., vol. lxi, p. 313, 1905.

to our knowledge of Antarctic fossil floras that has yet been published. It is true that Hope Bay, Graham Land (lat. 63° 15′ S.), lies without the Antarctic circle, but, as the author justly points out, the present climate of this region is purely Antarctic and its known flora includes only two species of the higher plants.

It is very remarkable to find that of the specimens from Graham Land, collected by members of the Swedish South Polar Expedition (which are not only far more numerous but much better preserved than those obtained in the Antarctic region either before or since), not a few are the same species as those with which we have long been familiar in the Lower Oolites of the Yorkshire coast. No less than nine of the species, including ***Todites Williamsoni*** (Brongn.), ***Cladophlebis denticulata*** (Brongn.), and ***Coniopteris hymenophylloides*** (Brongn.), are British plants, and a very large proportion of the genera are also found in England. Surely current opinion with regard to the worldwide distribution of Mesophytic vegetation could receive no more striking confirmation than is to be found in Dr. Halle's memoir.

The author distinguishes sixty-one Jurassic types either generically or specifically, and full and clear descriptions are given of each. Of these, twenty-one are new species, and two (***Elatocladus*** and ***Schizolepidella***) are new genera. The systematic portion of the work is followed by a discussion, at considerable length, on the known geographic distribution of the plants and the age of the beds, which are regarded as Middle Jurassic.

Dr. Halle may be congratulated on the results of his labours, and our thanks are due to him for the care and research which he has obviously bestowed on the preparation of this memoir. It is no doubt true that the study of fossil plants demands, perhaps more than any other subject, an accurately balanced judgment. Dr. Halle has shown, by the way he meets the difficulties presented by this material, that he is possessed of such judgment in a high degree. Many of the suggestions which he makes with regard to difficulties arising from homoplasy and synonymy are worthy of careful attention at the hands of all those who are working in the same field. We may also congratulate Professor Nathorst on the achievement of his pupil, whom he has obviously inspired with something of his own enthusiasm, care, and discrimination.

In conclusion, a word of praise may be added with regard to the clearness and general excellence of the plates (eight double and one single) which accompany and illustrate the memoir.

E. A. N. A.

II.—Geological Survey Memoir.

The Geology of the Country around Ivybridge and Modbury. By W. A. E. Ussher, F.G.S., with chapter on Altered Rocks by G. Barrow, F.G.S. 8vo; pp. vi, 137, with 6 plates and 26 text-illustrations. Printed for His Majesty's Stationery Office, 1912. Price 3*s*.

THIS is an explanation of the colour-printed Geological Survey map, Sheet 349. It takes in the eastern part of Plymouth, and adjoins Sheet 348, which was described by Mr. Ussher in "The

Geology of the Country around Plymouth and Liskeard" in 1907. The series of formations, stratified and igneous, in the two areas are for the most part the same, but there are certain local differences, and some modifications appear in the tabulation of them in the two memoirs.

The story of successive attempts to unravel the sequence in the South Devon rocks is well told in the Introduction, and it is noteworthy that the founders of the Devonian system had failed to determine the true sequence in the subdivisions which they recognized near Plymouth. Although the Rev. Richard Hennah is only mentioned in the Bibliography, a brief record of his local researches was given in the Plymouth memoir (p. 2), as "he was the first to point out the presence of organic remains" in the Plymouth limestone. It may be mentioned that he was Chaplain to the Garrison of Plymouth from 1804 until his death in 1846, and that the loan of his collections of fossils to Sedgwick, Murchison, and Lonsdale "afforded one of the principal sources for determining the relative geological age of the Devonian limestones".[1]

According to Mr. Ussher, the work of Jukes in 1867–8 "is of great stratigraphical value", and "he supplied an entirely new and correct rendering of the stratigraphy of the coast-section south of Plymouth". Subsequent observers, notably Holl and Champernowne, added much to the knowledge of the strata, but did not succeed in determining the true structural arrangement.

No one has laboured so long, so earnestly, and so laboriously at the interpretation of this and adjacent areas as the author of the present memoir, nor has anyone more fully realized the difficulties that are encountered. While carrying out the detailed survey on the 6-inch maps during the years 1892–7 he blocked out the main subdivisions in the strata, determined their sequence, and the equivalent rocks in adjacent areas; but, while surmounting so many of the graver difficulties, he was obliged in some tracts to leave with doubt the precise grouping of the strata. In particular he mentions the uncertainty of the boundary between Middle and Upper Devonian in the slate areas, as no fossils distinctive of the lowest beds of the Upper Devonian have been found. Moreover, the higher beds of the Plymouth limestone include portions of Upper Devonian, the zone of *Rhynchonella* (*Wilsonia*) *cuboides*, as in other areas of South Devon, and no definite plane of demarcation can be fixed between the divisions. Again, in the Lower Devonian the lines drawn between the subdivisions on the map are stated to be often uncertain. The author, however, is in his element when recording in detail the results of his observations in the field and the perplexities with which he had to deal. To anyone following in his footsteps the particulars will be of great service, but they are given at the expense in most cases of more readable, if brief, accounts of the leading lithological and palæontological features of each subdivision. Now that the area around Plymouth has been completed, it may be that the authorities will issue a special colour-printed map of Plymouth, like that of Nottingham and other places, accompanied by a memoir; and these

[1] Obituary of Hennah, by L. Horner, in Address to Geol. Soc., 1847.

would be of service to those who want to gain readily a general knowledge of the geology. It is a curious fact that, despite the detail concerning the rocks, no particulars are given in the text of the fossils determined by Dr. Kayser and Dr. Henry Woodward, as acknowledged in the Director's preface.

The contemporaneous igneous rocks include sheared lavas and tuff in the Lower Devonian, schalsteins and diabases in the Middle Devonian, and vesicular lavas and tuffs of the spilite (pillow-lava) type, also diabases, in the Upper Devonian. The intrusive rocks include a large tract of granite forming the southern part of Dartmoor with the Lee Moor china-clay works; also felsite, rhyolite, granophyre, and some basic rocks. Considerable interest attaches to the metamorphic aureole which borders the granite, the altered rocks being described by Mr. George Barrow. Certain banded siliceous and slaty rocks, which appear originally to have been carbonaceous shales and grits, are grouped by Mr. Ussher with the Culm-measures. Less certainty arises with the grouping of tracts of calc-flints, which might be Devonian or Carboniferous. These hard flinty rocks, according to Mr. Barrow, have resulted from the alteration of calcareous sediments by pneumatolytic action, and there have been developed in them such minerals as axinite, garnet, datolite, etc. Dr. Teall has contributed some notes on the subject (not, however, indicated in the text). Allusion is made to the possible occurrence of a 'New Red Sandstone' deposit, which was originally noted by Sedgwick and Murchison, but is now so much obscured by rainwash and talus that no confirmation of the occurrence can be given. Some relics of Tertiary, possibly Eocene, strata are described; then follow short accounts of the cavern deposits, head, river gravels, rock valleys and deposits below high-water mark, submerged forests and peat. In the chapter on Economics the subjects include water supply, metalliferous mines (with notes by Mr. D. A. MacAlister), china clay, building-stone, marble, road-stone, slate, lime, peat, and soils.

The plates are good, notably that of an elvan in Upper Devonian slate at the Cann Quarry; and, needless to say, the colour-printed map Sheet 349 (price 1*s.* 6*d.*) is excellent, and well shows the great progress made by the Geological Survey, and by Mr. Ussher in particular, in elucidating the structure of South Devon.

III.—A Descriptive Catalogue of the Marine Reptilia of the Oxford Clay, based on the Leeds Collection in the British Museum (Natural History), London. Part II. By Charles William Andrews, D.Sc., F.R.S. 4to; pp. i–xxiv and 1–206 (including index), with 73 text-figures and 13 plates by Miss G. M. Woodward, and collotype frontispiece. Printed by order of the Trustees of the British Museum by Taylor & Francis, London, 1913. Price 25*s*.

THE appearance of the second volume of this Catalogue calls for the heartiest congratulations to all those responsible for the production of this highly valuable work. It must certainly be reckoned among the most important works of reference that have emanated from the Natural History Department of the British Museum. Its execution could not have been entrusted to more capable hands than those of Dr. Charles W. Andrews, who deserves the warmest praise for the high degree of skill and scientific learning which he has applied to the completion of a task requiring close and protracted study to bring it to so successful a termination. The publication of these two volumes is the more welcome, as for the first time it allows us to obtain an adequate idea of the enormous mass of extremely valuable material contained in the Leeds Collection. It must be a matter of no little satisfaction to Mr. Alfred N. Leeds to see brought together in these volumes the valuable results thus obtained for palæontological research by nearly fifty years of careful excavation and observation, coupled with patient labour in restoring the specimens from innumerable fragments.

The present volume is devoted to a second branch of the Plesiosaurs, namely the Pliosauridæ, and to the Crocodilia, which are particularly richly represented in this collection. Following the method adopted in the first volume, the author has initiated the description of the various species belonging to these classes by an admirable Introduction, in which he sets forth the main results of comparative research into the relations of the Oxford Clay Reptilia with those of earlier and later deposits. In the evolutionary history of the Crocodilia nothing new has been ascertained, nor has much new light been thrown on the problems surrounding the Sauropterygia. But Dr. Andrews is led apparently by his studies for the purposes of the compilation of this Catalogue to lay aside an earlier opinion that the latter group is allied to the Rhynchocephalians, and now declares himself an adherent of the view expressed by A. S. Woodward and Williston that it is to the Theriodontia that we must look for their origin. On the other hand, Dr. Andrews is unable to assent to Williston's attempt to define the Pliosauridæ, and notes certain differences in the relations of the sphenoids to the pterygoids as compared with the Cretaceous *Trinacromerum*, although in the relationships of the frontals and parietals he finds the Pliosaurs to be nearer akin to the North American than to the European Plesiosaurs. This latter important modification of his earlier description of the skull of the principal specimen of *Pliosaurus ferox* has emerged in the course of examination of a large number of examples of Pliosaur skulls, particularly of *Peloneustes*. In addition to the new species *Simolestis vorax*, other recent acquisitions by Mr. Leeds have included a large Pliosaur, temporarily referred to *Peloneustes Evansi*, though it is found to differ so considerably from the genus, which was created by Lydekker for the reception of *Pliosaurus philarchus*, that Dr. Andrews hints at the necessity of its ultimate assignment to an entirely new genus. Highly interesting is the occurrence in this series of some of the bones of a young animal. It is to be regretted that no figure was included, as it would have given a far clearer idea of the extraordinary changes which took place in such bones as are known before the fully adult state was reached. Although the ribs are well described, no account even is given of the ischium, which by reason of its extraordinary massiveness, with additional thickness at the centre, is the exact inverse of what is found in full-grown animals. One may wonder whether the bad preservation of Pliosaurian dorsal vertebræ from the Oxford Clay may not be due in a large measure to the retention through life of the spongy texture so noticeable in the bones of the young animal. That some peculiarity pertained to this genus seems to follow from the fact that, though distortion from pressure is not uncommon in other classes of Reptilia from this deposit, when it does occur it is not as a rule confined to the dorsal region, whereas in the Pliosaurs the dorsal vertebræ are practically never found in any other condition.

Dr. Andrews had already published an anticipatory account of the various species which he has distinguished among the large series of Teleosaurian Crocodilia, but in this, the final presentation of the results of his researches, he not only includes a new species in *Steneosaurus hulkei*, but finds himself compelled to refer to an entirely new genus, *Mycterosuchus*, the specimens formerly described as *Steneosaurus nasutus*, possessing as it does marked differences in the structure of some of the vertebræ, the form of the skull and the humerus, and the relative size of the fore and hind limbs. In this connexion it is now shown that in the Steneosaurs, at least, the general characteristics of particular bones in any given species are present throughout the whole skeleton; thus *St. Leedsi*, with its slim and slender skull, is associated with sharper teeth, longer and more slender vertebræ, with lighter neural spines. It should now be possible to refer almost any isolated bone to its proper species. It is interesting to note that, though the author can find among the Peterborough Steneosaurs no species exactly comparable with those from the same strata in Northern France, he fully admits in his account of *St. hulkei* (of which an illustration would have been welcome) the possibility that what are regarded in this Catalogue as specific features may be in part nothing more than age-characters. This statement is important, and is only here rendered possible by the extensive series of skulls, all derived from the same area. On the other hand, it has to be remembered that the variant form of coracoid, as shown in figs. 69 and 70, is found in fully developed representatives of one and the same species.

The genus *Metriorhynchus* vies successfully with *Ophthalmosaurus* in its frequency in the Peterborough deposits, and is represented in this Catalogue by an unusually fine series of skulls, among which Dr. Andrews recognizes no less than seven species. This is the first time that any comprehensive account of this genus, as found in England, has been published, and the author is to be congratulated on the moderation which he has displayed, amid such a wealth of material to choose from, in creating new species. Here, again, it is probable that age-characters may be responsible for many of the variations which would undoubtedly have aroused some palæontologists to indulge in a perfect orgy of terminological invention. With the distinctions drawn in this Catalogue there can be no complaint on that score. In this genus we come more into touch with the Normandy crocodiles, no less than three species named by French scientists being identified in England also. Three species, *M. læve*, *M. Leedsi*, and *M. cultridens*, are, however, entirely new and have not been previously described. The seventh, *M. durobrivense*, was known as long ago as 1890, but was then called *Suchodus* by Lydekker. It has now, and without a doubt correctly, been assigned to *Metriorhynchus*. An excellent and most useful figure (No. 73) enables the principal points of difference in the skulls of these seven species to be obtained at a glance, though it is doubtful whether both this figure and plate xi are not liable to convey a somewhat false impression as to the nature of the sculpture of the frontal bones of *M. cultridens*. The species is based on R. 3804, an example in which these bones, when found, were covered by hard concretionary matrix, such as is still visible on the palatal surface, and the process of freeing the bones from this matrix has seldom been executed without the removal of parts of the surface of the actual bone along with it. Such parts, however, as are still uninjured suggest that the sculpture must have closely resembled that of *M. brachyrhynchus*. On the other hand, a view of the uncrushed posterior aspect of this skull would probably have given a better idea of the form of this region than that of *M. durobrivense* on plate xiii, which has admittedly suffered some compression.

One result of Dr. Andrews' examination of this genus is that he entirely discards as an unreliable criterion the measurement across the prefrontals, hitherto employed as one of the standard dimensions for recognizing the various species.

No mention is made of ventral ribs in connexion with *Metriorhynchus*. These, though scarce, are not unknown, but perhaps are not contained in the Museum collections. It would have been interesting to know whether Dr. Andrews would have regarded them as another characteristic acquired by the Metriorhynchidæ, in accordance with their more aquatic habits, which led them to discard the dermal armour with which the amphibious Teleosaurs were protected.

The comparison of the Metriorhynchidæ with the slightly later Geosauridæ is interesting and useful, but we hardly think that it called for the insertion in a Catalogue of English Oxford Clay Marine Reptilia of a whole-page illustration of a specimen of *Geosaurus*, a genus which must already be familiar to all students of vertebrate palæontology from Continental works. Skeletons of Geosauridæ, in the condition in which the Metriorhynchidæ have been recovered from the Oxford Clay, are unknown on the Continent, and even if no skeleton of *Metriorhynchus* was considered worthy of the honourable position of the frontispiece, surely some other, for example the typically Oxfordian *Peloneustes*, might well have had this plate allotted to it. It may argue for a greater degree of cosmopolitanism on the part of English scientists, but it is well-nigh inconceivable that any continental scientific institution would have figured in a similar position a skeleton from England, however much they might have been alive to its importance for comparative study. In any case, in the present instance the result can hardly be said to justify the decision which prompted its insertion. Apart from this the illustrations leave little to be desired. They are executed with all her accustomed skill by Miss Gertrude M. Woodward, and form a great enhancement to this valuable work. The admirable plates, thirteen in number as compared with ten in the first volume, are mainly devoted to skulls of which more specimens are forthcoming than in the sections dealt with in the companion volume, rather, indeed, to the exclusion of other parts of the skeleton. The reduction in size of many of the text-figures is a great improvement to their appearance, while detracting nothing from their value.

May we hope that the success which has attended the publication of this Catalogue of the first rank may induce the Trustees to sanction the production of a companion volume on a similar scale which shall bring together the remainder of the remarkable treasures of the Leeds Collection, namely, the Fishes and the Dinosaurs, with, perhaps, the tail of *Leedsia problematica* as a frontispiece?

IV.—Geology of the Federated Malay States.

The Geology and Mining Industry of the Kinta District, Perak, Federated Malay States. With a geological sketch-map. By J. B. Scrivenor, M.A., F.G.S. 8vo; pp. 91, with 11 text-illustrations and 20 plates. Kuala Lumpur, 1913. Price 3 dollars (about 5*s.* 3*d.*).[1]

THIS memoir is descriptive of a tract in the north-western part of the States, the Kinta River, which traverses the area, being one of the chief tributaries of the Perak River. Granite mountains, the Main Range and the Kledang Range, border the country on the east and north-west respectively, while the intervening valley region is occupied firstly by limestone, containing pipes and fissures with detrital tin-ore, and then by coverings of Gondwana Beds and superficial deposits. It has not been deemed advisable to colour on the map the Alluvial beds, as they somewhat obscure the metalliferous strata, and the object is essentially a practical one. In old days the recent Alluvium was an important source of tin-ore, but this is no longer the case.

The limestone forms a rugged floor to the valley, but it is difficult in many places near the river to determine the limits of the overlying clayey and sandy strata of the Gondwana formation. In several localities the limestone rises in precipitous hills due primarily to displacement, the cliffs in fact being fault-faces with the basement Gondwana rocks (Gopeng Beds) faulted down against them.

There is evidence that the limestone and Gondwana rocks were covered at one time by "a huge pile of younger rocks", and that all were crushed and folded, and bent as a whole into a low anticline. These disturbances were caused by the intrusion of the granite, which was probably separated at some depth from the limestone by "a considerable thickness of still older rocks" that were broken up "and perhaps completely dissolved in the granite magma". The granite is stanniferous, and prior to its complete solidification "spurts of vapour and molten rock, carrying tin amongst other things"

[1] On sale at the Malay States Agency, 88 Cannon Street, London, E.C.

penetrated the bordering rocks. Subsequent denudation has led to the production of the present physical features.

The limestone is characterized by its crystalline structure, and although sometimes banded with black layers it is usually a beautiful white saccharoidal marble. The prominent limestone hills before mentioned are regarded by the author as "large blocks of the crust that sank on to the granite magma, relatively less than the surrounding rocks when the Main Range anticline broke up". No palæontological evidence has been obtained to prove the age of the limestone in the Kinta valley, but in Pahang the same limestone, less altered, contains Carboniferous fossils. It is the oldest known rock in situ in the Federated Malay States, there being no justification for the statements that have been published concerning the presence of Archæan rocks.

In describing the Gondwana rocks the author discusses the evidence which leads him to regard the basal clays with boulders as of glacial origin. The clays all contain a certain amount of sand which yields tin-ore and other minerals. In the western part of the area the boulders are mostly tourmaline-corundum rocks; in the eastern part (Gopeng, etc.) pure corundum boulders occur, as well as a greater variety of other rocks. Referring to the Gopeng clays the author considers that their constitution and the field evidence clearly point to the tin-oré having been derived, with the other minerals, or the bulk of them, from some mass of tin-bearing granite and associated altered rocks, distinct from and older than the Main Range (Mesozoic) granite. At Tekka there are sections showing that the clays are altered by this granite and invaded by veins of it. It is noteworthy, however, that no clear evidence has been seen of striations or of polished rock-surfaces. The overlying Gondwana rocks comprise chiefly phyllites and quartzites, with also mica-schists, tourmaline-schists, and shales. These newer rocks contain cassiterite, which the author believes to be an original detrital constituent.

The latest accumulations are those of the lignite and Alluvium; indeed, the lignites and associated sands appear to form part of the Alluvial deposits, and their thickness in some places "may indicate a long period of deposition in pools or lakes over an area where rapid solution of the limestone bed-rock below led to a steady subsidence of the surface of the ground".

The concluding portions of the memoir contain particulars of the principal tin-mines and notes on other minerals found in the district. The numerous plates illustrate by excellent photographs some of the physical features of the country, faulted tracts, rock-formations, boulders, mine-works, ore-deposits, and micro-sections of rocks.

V.—United States Geological Survey.

BULLETIN 494 (1912) is on "The New Madrid Earthquake", by Mr. Myron L. Fuller. This somewhat ancient earthquake, named after New Madrid in Missouri, comprised a succession of shocks, beginning on December 16, 1811, and lasting more than a year. At that time the region was almost devoid of settlers, and the published accounts were few; nevertheless, the results of the disturbance caused it to be regarded as one of the great earthquakes of the world, and according to Mr. Fuller it may be taken as a type, exhibiting in unusual detail the geologic effects of great earth-movements upon unconsolidated deposits. The area affected was in the Central Mississippi Valley, including South-Eastern Missouri, North-Eastern Arkansas, and Western Kentucky and Tennessee. After gathering the information previously published, and calling special attention to the graphic account given by Lyell, the author describes many features still well preserved, among them fissures and faults, the former in many cases being infilled with intruded sand (sand-dikes).[1] Other features comprise sunk lands, among which are sand sloughs or broad and shallow troughs with ridges covered by extruded sand (sand-blows); also certain river-swamps, and tracts with lakes. Thus Reelfoot Lake in Tennessee, which is 8 or 10 miles in length and 2 or 3 in breadth, indicates a submergence of from 5 to about 20 feet, and rising from its waters there are still numerous shattered stumps of trees that flourished prior to the catastrophe. The earthquake is attributed to earth-movements "associated either with the processes of folding or warping, or incident to a depression and deepening of the basin". The subject is well illustrated with maps, diagrams, and pictorial views.

Bulletin 499 (1912) contains an account of "Coal near the Black Hills" on the borders of Wyoming and South Dakota, by Mr. R. W. Stone. Cambria is the only place where good workable coal has been found over a considerable area. It occurs in the Lakota Sandstone (Cretaceous), and it is remarkable that the sedimentary strata and the coal itself contain both gold and silver. In the coal the average value per ton of the gold is $2·46, and of the silver $·28. The author remarks that "the most plausible explanation seems to be that the sands which submerged the swamp and now form the roof of the coal-bed were derived in part from old gold-bearing alluvium. . . . Currents which transported the sand and the grit which occur in some places a few feet above the coal certainly were strong enough to transport fine gold. While the sand was being deposited the gold may have worked down into the underlying bog and is now found in the coal".

Bulletin 500 (1912) is on the "Geology and Coal-fields of the Lower Matanuska Valley, Alaska", by Messrs. G. C. Martin and F. J. Katz. The formations include (1) various schistose rocks, classed as Palæozoic, (2) greywackes, slates, and igneous rocks, classed as Early Mesozoic or older, (3) Jurassic, (4) Cretaceous, (5) Tertiary, and (6) Quaternary. The coal-bearing strata belong to the Chickaloon formation of the Eocene, which covers the greater part of the valley of the Chickaloon river, south of Castle Mountain. In thickness the formation appears to be at least 2,000 feet, and it consists of shales and sandstones with ironstone nodules and seams of coal, also many plant-remains, chiefly leaves. Much of the coal is of high-grade bituminous character. Seams occur in thickness up to about 14 feet, but these are often shaly, and the thickness is usually much less. The outcrops occur generally at steep angles.

[1] See also article by Dr. A. P. Pavlow, GEOL. MAG., 1896, p. 49.

The general geology presents many points of interest and is illustrated by coloured geological maps and pictorial views; there is also a map of Central Alaska, showing the position of the coal-fields.

VI.—Underground Water Resources of Iowa.

THE twenty-first volume of the Iowa Geological Survey contains the Annual Reports for 1910 and 1911, with statistics of the Mineral Production of the State for 1909 and 1910; but it is occupied mainly by a connected series of reports on the Underground Water Resources. The result, a huge quarto volume of xvi + 1214 pages, has been issued under the direction of Mr. George F. Kay, the State Geologist. The investigation of the water-supply was initiated by the late Samuel Calvin, and since 1903 it has been carried on in co-operation with the United States Geological Survey.

The artesian waters have been studied in particular by Mr. W. H. Norton (geologist for underground waters); the waters of the Drift and Country Rock, or the ground waters, are dealt with by Messrs. Howard E. Simpson and O. E. Meinzer, and their chemical and industrial qualities are discussed by Professor W. S. Hendrixson. Here it may be mentioned that the term 'country rock' is applied to "the rock which outcrops at the surface or immediately underlies the drift"; while the term 'aquifers' is given to the 'water-beds', or, as we should call them, the water-bearing strata.

The artesian aquifers are mostly deep-seated and of early Palæozoic age, but the strata naturally approach and come to the surface in places, where they might be included in the country rocks.

Iowa State is divided into ninety-nine counties, and fortunately the Geological Survey, having very nearly completed the field-work of the entire area, had also accumulated much information relating to the geologic conditions which control the ground water. Further particulars, as full as possible, have now been gathered from the officials of each town and from well-drillers in connexion with the underground water-supply. It is justly remarked that with regard to the artesian waters "there is needed the skillful interpretation of data collected from a wide area, a knowledge of the geological structure and acquaintance with the distribution and movements of deep waters", as "the local well driller cannot be expected to know either the quantity or quality of artesian waters or the depth at which they can be reached".

Many useful hints are given on the collection and preservation of samples from borings, on the errors that may arise in the determination of the nature and thickness of the rocks by means of drillings and the contents of slush-buckets, the difficulty and rarity of getting precise palæontological evidence, and of the local experience necessary in determining the age of formations by lithological evidence.

These and other matters are discussed by Mr. Norton in an Introduction to the general account of the Underground Water Resources. The Topography and Climate are dealt with by Mr. Simpson; the Geology by Messrs. Norton and Simpson, who give a useful table of formations, with their lithological characters. Particulars are given of the geologic occurrence of the underground waters, and of the effects due to the inclination and undulations in the strata of the artesian system, chiefly thick sandstones in the Cambrian and Ordovician. The Cretaceous System also contains much artesian water in the Dakota Sandstone, while the Pleistocene or Drift sands and gravels "yield supplies to innumerable shallow wells in nearly all sections and are the most important source of water in the State". The term artesian is rightly used to include not only the water of flowing wells, but also well-waters that rise to a considerable height within the tube under hydrostatic pressure.

After the general remarks on the Underground Waters, the subject is treated under eight districts, each including a number of counties, the object being to furnish to each community, so far as possible, information on the artesian water, whether it can be found at certain localities, at what depth it may be reached, through what formations the drill must pass, what mineral compounds (healthful or harmful) the water is likely to contain, how high it will rise, how large will be its discharge, with remarks on its probable permanence. Geologists in this country are chary in giving forecasts of the quantity of water likely to be obtained from a boring, and it is usually thought sufficient to give an estimate of the probable depth at which water would be reached. Indeed, in the present work Mr. Norton advises that "contracts for artesian wells should make provision for drilling at specified rates for several hundred feet beyond the supposedly necessary depth". At the same time, many official predictions have proved accurate enough for practical purposes, as in cases where the estimate was 700 to 750 feet and water was found at 715, or the estimate was 800 and water occurred at 780, or the estimate was 1,300 to 1,500 and water was found at 1,408 feet.

One of the more remarkable water-bearing formations in Iowa is the St. Peter Sandstone of the Ordovician, and it is the highest aquifer of the Palæozoic Series. A map of the State has therefore been given to show by contours the elevation above sea-level of the top of the sandstone, with contours also of the artesian head of water. Along its outcrops it is a massive homogeneous bed of 'millet-seed' sand. Below ground it is said always to yield some water, and in many places an abundant supply. There is also a Drift map of Iowa, showing the coverings of Kansan, Illinoian, Iowan, and Wisconsin Drifts, also the driftless area. In fact, no pains have been spared to make the volume an eminently practical and reliable work of reference.

VII.—Did Coral-reefs exist in the Palæozoic?

Les récifs coralliens existent-ils dans le paléozoique? By N. Yakowlew. Bull. du com. géolog., tome xxx, No. 201. pp. 847–57. St. Pétersbourg, 1911.

In this contribution the author states the views he has arrived at on this subject after more than ten years of geological research among the Palæozoic rocks of the Ural, Timan, Donetz Basin, and the Courlande. In the reefs found in the Palæozoic rocks, as exemplified by the Carboniferous of Belgium, Devonian of Germany and Poland, and the Silurian of Gotland, the *Zoantharia* (*Rugosa* of the Palæozoic rocks) play a less important part than they do at the present day. The main constituents of these Palæozoic reefs are *Stromatoporoidea*, and next to them in importance come the *Tabulata*, and lastly the *Rugosa*. Reefs which are entirely composed of rugose corals are unknown.

M. Yakowlew has discovered reefs formed exclusively of *Stromatoporoidea* in the Devonian of the Courlande, and reefs made up for the most part of *Stromatoporoidea* in the Carboniferous of the Timan. The reefs found in the Middle Devonian of Poland are formed of *Stromatoporoidea*, together with some *Rugosa* and *Tabulata*, while less extensive coral masses composed essentially of *Tabulata* are found in the Upper Devonian.

An examination of the views of Grabau and Vaughan on the coral reefs of the Palæozoic rocks, chiefly American, leads M. Yakowlew to the opinion that the conclusions of these authorities on the subject of the analogy of the coral reefs of the Palæozoic and posterior epochs are not confirmed by the facts that they quote. He does not see any analogy between the 'knoll-reefs' of Grabau and of Tidemann [Tiddeman] and the reefs of the present day. The view expressed by Bonney that conditions other than those of the present time might have influenced the formation of reefs in the Palæozoic period appears to him to be more acceptable.

I. T.

VIII.—A Monograph of the Cretaceous Lamellibranchia of England. By Henry Woods. Palæontographical Society, 1899–1913. 14 parts, making 2 vols. 4to; pp. i–xliii, 1–232, 42 plates; pp. 1–473, 62 plates.

THE completion of so monumental a work demands more than a passing notice. Mr. Woods has given us a reference book of the utmost value for the identification of our Cretaceous fossils. The valuable bibliography and the excellent and full synonymies must lighten the labours of all future workers and give a final opinion on all questions of nomenclature. Throughout the whole work there is evidence of the utmost care, although in the last part signs are not wanting of weariness in the very brief account of the Radiolitidæ and the paucity of the "Additions". There are still a number of new things in public and private hands awaiting description, and perhaps Mr. Woods may be induced to return to them after a brief rest. The Gasteropoda and the Cephalopoda now want tackling to round off the Molluscan fauna of the English Cretaceous.

The illustrations have maintained a high standard throughout the work, and in the two groups of the Inocerami and the Ostræidæ the Council of the Palæontographical Society has with wise generosity allowed Mr. Woods remarkable freedom. We therefore see not only one specimen of each species properly figured but whole series of each species displayed, showing all the varieties of shape that the species exhibits. It is therefore now possible to determine nearly all the puzzling anomalies of a species of these genera with an ease and certainty hitherto quite impossible.

One criticism Mr. Woods must allow us to make, if only for the guidance of the editor; that is, that in these days of accurate collecting, it is essential that the name of the collector should be inserted after the name of the locality, whenever known. It would add very greatly to the value of such a monograph as this to know that Dr. Blackmore, for instance, was responsible for the statement that *Ostrea semiplana* occurred in the zone of *Act. quadratus* of East Harnham. In the present case such proof is not forthcoming. We congratulate and thank Mr. Woods for the valuable work he has completed.

IX.—Brief Notices.

1. Southern Rhodesia.—The Report of the Director of the Geological Survey, Mr. H. B. Maufe, for 1911 (1912), records the wide distribution of tin-bearing rocks; notes that the majority of the productive gold-mines do not lie in the schist-belt as is generally thought, but in a peculiar granitic mass, named the Mont d'Or granite; and refers to the important chrome iron-ore deposits which occur in a mass of serpentine and talc-schist.

There are special reports (1) on the geology of the country around Selukwe, by Messrs. A. E. V. Zealley & B. Lightfoot, with a general introduction by the Director; (2) on the geology of the Victoria Tin-field, by the Director; (3) on the asbestos quarries, Victoria District, by the Director; (4) on the claims of the Great Sabi Coal Syndicate, Victoria District, by Mr. Lightfoot; (5) on claims pegged for aluminium near Selukwe, by Mr. Zealley; and (6) on a traverse from Gwelo to Bulawayo, by Mr. Zealley. With regard to the asbestos Mr. Maufe observes that it consists of the fibrous form of serpentine, known as 'chrysotile asbestos'.

2. Meteoric Iron from Perryville, Missouri.—The block, which weighed about 17½ kilograms, was found in an open field, about three-fourths buried in the soil. It is described by Mr. G. P. Merrill (Proc. U. S. Nat. Museum, xliii, December, 1912), who records, among ordinary constituents, traces of iridium, palladium, platinum, and ruthenium. The author states that so far as he knows this is the first authentic instance of the occurrence of ruthenium in a meteoric iron.

3. Underground Waters of Poitou.—In "Spelunca" (Bulletin et Mémoires de la Société de Spéléologie, ix, September, 1912), Professor Jules Welsch records the results of his detailed studies of the "Hydrologie souterraine du Poitou calcaire", in the Departments of Vienne, Deux Sevres, and Vendée, which together coincide closely with the old province of Poitou. After describing the general physical features and geological structure of the region, he deals in particular with the areas of Jurassic limestones from the Lias to the Corallian, etc. (Rauracien-Séquanien). Water-bearing horizons occur throughout the series, but they are most copious in the Bajocian and Bathonian. The sources of the waters, their circulation as affected by dislocations, folds, faults and fissures, the caverns, swallow-holes,

underground channels and springs, are very fully described, with remarks on sources of contamination.

4. Iridosmine in the Transvaal.—This alloy was discovered several years ago by Mr. A. F. Crosse in the Rand bankets. Its occurrence in the New Rietfontein Mines is recorded by Mr. C. Baring Horwood (Trans. Geol. Soc. South Africa, xv, 1912), and he describes it as an intimate mixture of iridium and osmium, generally with ruthenium, and sometimes with a little platinum, chromium, gold, and palladium. The metals in the banket reefs, in his opinion, are of secondary origin, having originated as segregations formed by magmatic concentration in the basic eruptive rocks of the mines, and from these dykes they were extracted by the action of superheated gases. Later still, hydrothermal action probably played an important part in concentrating them in the banket reefs.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

March 6, 1913.—Sir Alfred Kempe, Vice-President and Treasurer, in the Chair.

The following communications were read:—

1. "The Evolution of the Cretaceous Asteroidea." By W. K. Spencer. Communicated by Dr. A. S. Woodward, F.R.S.

An endeavour is made to trace the evolution of the Starfish through the whole of the Cretaceous deposits. At the first sight the material appeared to be unpromising, for complete or even fragmentary specimens are rare. It has been found possible, however, to use the isolated marginal plates which are found fairly commonly on weathered chalk surfaces. It is shown that these marginal plates have a shape and ornament characteristic of each distinct species. The species may be arranged in lineages, and the examination of large collections made by English and Continental workers make it feasible to trace the life-history of most of the lineages. Each lineage shows definite stages of advance (elaboration) followed by stages of regression. Occasionally a lineage will re-elaborate after passing through the regression stages ('rhythmic' or 'periodic' variation). Elaboration and regression are closely parallel in the lineages. They consist of changes in the size, the height, and the character of the ornament of the plates.

Variation as shown, both through measurements and by general examination, is, in general, of the 'continuous' type. Discontinuous variations ('saltations') are known, but they appear to be relatively of little importance. The measurements also show (1) that there is close connexion between the general vitality of the race, as shown by its range of variability, and the rhythmic phases alluded to above; (2) that the rate of elaboration is affected by environment.

It has not been found possible to show that selection plays any predominant part in the evolution of the lineages, and it is suggested that inborn racial character is the predominant influence in causing modification.

The bearing of the research upon various problems in stratigraphy is considered, especially in relation to recent research by Brydone, Niellsen, Ravn, and Rowe.

2. "A Preliminary Note on the Fossil Plants of the Mount Potts Beds, New Zealand, collected by Mr. D. G. Lillie, Biologist to Captain Scott's Antarctic Expedition in the *Terra Nova* in 1911." By E. A. Newell Arber, Sc.D. Communicated by Professor T. McK. Hughes, F.R.S.

The communication briefly discusses the first results which have reached this country of the late Captain Scott's second Antarctic Expedition. In the winter months of the last two years the *Terra Nova* has been at work in New Zealand waters. During these periods Mr. D. G. Lillie, one of the biologists of the Expedition who has been attached throughout to the *Terra Nova*, has been endeavouring to clear up on the evidence of the fossil floras some of the many points which remain unsolved with regard to the stratigraphical geology of New Zealand. In particular, he has made large collections from the Mount Potts Beds, in Ashburton County, Canterbury. Whether these beds contain *Glossopteris*, as asserted by Hector and others, has long been a matter of dispute, for the whole question whether New Zealand formed part of the great Southern Permo-Carboniferous Continent of 'Gondwanaland' depends entirely on the character and age of the flora of these beds.

As it proves, the flora of these beds is thoroughly Mesozoic. It is true that one of the most striking plants represented is one which very closely simulates *Glossopteris*, but the lateral nerves do not anastomose. This genus is already known from the Rhætic of Chili, and has been referred by Solms to the Palæozoic genus *Lesleya*. It is, however, here referred to a new genus *Linguifolium*, and the New Zealand species is distinguished as *L. Lillieanum*, sp. nov. The associated species include a new species of *Chiropteris*, leaves of a *Baiera*, similar to the Rhætic *Baiera paucipartita*, Nath., with fronds of *Dictyophyllum acutilobum* (Braun), *Thinnfeldia lancifolia* (Morris), and *Cladophlebis australis* (Morris). In addition, the Upper Gondwana conifer, *Palissya conferta* (Oldh.) and fronds of *Tæniopteris Daintreei*, McCoy, occur.

The flora as a whole consists chiefly of Rhætic plants, though a few Jurassic types also occur, and thus the age of the beds is either Rhætic or Lower Jurassic. The Mount Potts Beds are admittedly the oldest plant-bearing series, in a geological sense, as yet discovered in New Zealand. No Palæozoic plants are known from these islands, and there is thus no evidence that they formed part of 'Gondwanaland' in Permo-Carboniferous times.

II.—Geological Society of London.

(i) *March* 5, 1913.—Dr. A. Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The 'Kelloway Rock' of Scarborough." By S. S. Buckman, F.G.S.

The author has studied the types of ammonites from the Kelloway

Rock described by Leckenby, preserved in the Sedgwick Museum, Cambridge, and a series of Yorkshire Kelloway Rock ammonites from the Museum of Practical Geology, London. He has grouped these ammonites according to their different matrices, and finds that they indicate several different zones. These zones he arranges in sequence, and suggests how they may be compared with the sections of Kelloway Rock of Scarborough given by Leckenby and by Fox-Strangways. The exact order of the zones is, in one or two cases, not considered to be proved, but the paper is offered with the idea of indicating where further work is required.

An examination of the ammonite fauna of the Yorkshire zones shows that the so-called 'Kelloway Rock' of Yorkshire is in part contemporaneous with the Oxford Clay of the Midlands and the South of England, and in part contains faunal facies not represented in these areas, but peculiar to Yorkshire so far as England is concerned; they show, however, some affinity with faunal facies in Russia and in Normandy.

An examination of the list of species of ammonites recorded by Fox-Strangways from the Oxford Clay of Yorkshire shows that the Oxford Clay of Yorkshire itself is not in the main sequential to the Kelloway Rock, but is contemporaneous with it, leading to the inference that even in Yorkshire itself part of the Kelloway Rock is only a local manifestation, and that it passes laterally into Oxford Clay.

A table of zones is given, in order to illustrate the contemporaneity of the Kelloway Rock - Oxford Clay deposits of Yorkshire and the Midlands, while at the same time showing the various non-sequences in both areas.

Some critical palæontological remarks are made concerning the identification of certain species of ammonites, and a correction of nomenclature is made, with a new name for a species misidentified on account of homœomorphy. This leads to a few remarks on development and homœomorphy, wherein an important difference in the mode of development of certain Kelloway Rock - Oxford Clay genera is pointed out, and it is remarked that there are three methods of homœomorphy—(1) subparallel, the likeness of stocks passing through similar stages; (2) transversal, the likeness of stocks starting from different forms meeting at a cross-over or collision-point; and (3) cyclical, the likeness of an anagenetic to a catagenetic series.

2. "On Jurassic Ammonites from Jebel Zaghuan (Tunis)." By Leonard Frank Spath, B.Sc., F.G.S.

Jebel Zaghuan, the best-known and most conspicuous, though not the highest, mountain of the Tunisian Atlas, is built up largely of massive bluish-grey limestones of confused stratification which have been referred to the Middle Lias on the evidence of badly preserved Belemnites and *Terebratulæ*, notably '*Pygope*' *aspasia*, *Columna* sp. Middle Liassic (Domerian) ammonites are now recorded for the first time. A new classification of the Domerian genera of the family Hildoceratidæ, to which the fossils from Jebel Zaghuan belong, is proposed.

Moreover, the ammonites collected by the author afford sufficient evidence of the presence of the zone of *Reineckia anceps*, which occurs in Algeria, but had been supposed absent in Tunis together with the other beds intervening between the Middle Lias and the Corallian. The Middle Jurassic transgression must, therefore, have begun in Lower Oxfordian times, since the deposits of that age probably rest directly on the Domerian.

The upper zones of the Oxfordian, as well as the lower part of the Corallian as interpreted by Mr. Buckman—that is, the *cordatus* and pre-*cordatus* zones—seem to be absent, although there is a possibility that they have been cut out by the extensive faulting, of which the general calamitization seems to afford proof.

On the other hand, the Argovian, or zone of *Peltoceras transversarium*, is very well represented. About seventy specimens were collected at a locality called Sidi Bu Gubrín, but the list includes forms from the *transversarius* zone mixed with some from the '*acanthicus*' beds. If we call to mind the curious fact that not only in thé Southern Alps but also in Sicily the Argovian is very well developed, to the exclusion of the higher beds of the Corallian, followed without any apparent break by the '*acanthicus*' beds, it appears quite probable that the two 'zones' occur here in a similar manner, and that the apparent mixture is not due to doubtful identifications of badly preserved specimens.

Most of the forms are certainly of Argovian age, and with regard to the remainder the stratigraphical value is problematical. The presence of the '*acanthicus* zone', therefore, must remain doubtful, although on the neighbouring Jebel Ben Saïdan deposits of that age occur, and indicate a third transgression in Central Tunis during Kimmeridgian times, which brought back the sea and gave rise to deposits of red ammonitic Knollenkalk exactly similar to that of the Lower Oxfordian and the Argovian.

(ii) *March* 19, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The President announced that the Council had awarded the Proceeds of the Daniel Pidgeon Fund for the present year to Roderick Urwick Sayce, B.A., University College of Wales, Aberystwyth, who proposes to investigate the rock-succession and structure of the Ystwyth Valley and its neighbourhood.

The following communications were read:—

1. "The Geology of Northern Peru: Tertiary and Quaternary Beds." By Beeby Thompson, F.G.S., F.C.S.

This paper deals with the physiography, physical history, and geology of some 600 square miles of territory in the westernmost part of South America, between the fourth and fifth degrees of south latitude, and between the Andes and the sea.

The connexion between the surface configuration of the district and the arid nature of the climate is shown.

A description is given of the tablazos, raised beaches, quebradas, and salinas, etc.

Then follows a physical history of the region, as told by the rocks themselves, from early Eocene times to the present. A great uplift and folding of the rocks took place in late Oligocene or early Miocene times, followed by a comparatively short terrestrial epoch A subsequent depression allowed of the deposition of Miocene and possibly later beds.

In what may be considered as recent ages the area has been spasmodically rising. It is shown that the elevation of the near Andes is a comparatively recent event.

The series of rocks exposed propably attain a thickness of 5,000 feet or more. The whole is divided into four groups of formations—Recent, Miocene, Oligocene (?), and Eocene, and each of these into sets of beds.

By far the most important of these groups of formations is the Eocene, in part corresponding to the Tejon of the Coatinga district of California. This yields abundance of fossils, and is the only series of beds that yield oil. Eight palæontological zones in this series are established. About 150 species of fossils are recorded, of which the larger proportion are probably new species.

The origin of the petroleum is traced to animal organisms.

2. "The Internal Cranial Elements and Foramina of *Dapedius granulatus*, from a specimen recently found in the Lias at Charmouth." By George Allan Frost, F.G.S.

The specimen described was found near the formation known as 'the fish-bed', in the *semicostatus* zone between Charmouth and Lyme Regis, and was embedded in an ovoid nodule of indurated Lias.

Owing to the complete envelopment of the skull and its subsequent pyritization, the bones and delicate interorbital septum are preserved in perfect condition, permitting the accurate delineation of the openings for the nerves. The bones apparently are completely ossified, and the entire build is massive, the heavy outer cartilage-bones receiving support internally from the well-developed orbitosphenoids. The supraoccipital, which alone exhibits signs of erosion, shows clearly the bony texture.

There is no foramen in the parasphenoid in front of the basipterygoid processes, as in *Lepidotus*.

The basicranial canal differs from that in *Amia calva*, in its extension to the rear of the skull, that in *Amia* ending in a cul-de-sac half-way.

The third, fourth, and fifth nerves in *Dapedius* have their most probable entry through a large median opening between the orbitosphenoids, and not as in *Amia* from the basicranial canal.

The opisthotics are stout and prominent bones, with an upward inclination corresponding to that of the parasphenoid.

The foramina for the optic and olfactory nerves are clearly shown, the latter nerve having been exposed for about two-fifths of its course across the orbit, thereby differing from *Amia* and *Lepidotus*, in both of which it is enclosed in canals.

There are two openings between each orbit and the nasal fossa.

The basioccipital exhibits a small condyle on each side, and is produced posteriorly in a process above the entrance for the notochord.

III.—Edinburgh Geological Society.

February 19, 1913.—Dr. John S. Flett in the Chair.

The following communications were read :—

1. "The Geology of Raasay." By Mr. H. B. Woodward, F.R.S. Communicated by Dr. John Horne, F.R.S.

The oldest rocks belong to the Lewisian Gneiss, and these are covered unconformably by the Torridon Sandstone, which includes representatives of the lower and middle divisions of that system. No Palæozoic rocks have been recorded in Raasay, but there is a splendid development of Mesozoic strata ranging from the Trias to the Great Oolite. The characteristic features of the Trias, the lower, middle, and upper divisions of the Lias, the Inferior Oolite, and the Great Estuarine Series were indicated. Mr. Woodward referred specially to his discovery of a band of oolitic limestone near the top of the Middle Lias, and approximately on the horizon of the well-known Cleveland ironstone of Yorkshire. The igneous rocks of Tertiary age occurring in Raasay and the prominent faults or dislocations affecting the strata were described.

2. "The Raasay Iron-ore." (Illustrated by diagrams, lantern plates, rock sections, and specimens.) By Mr. Wallace Thornycroft.

In his paper on the Raasay iron-ore Mr. Wallace Thornycroft stated that Mr. Woodward had drawn his attention to the account of the discovery of the Raasay iron-ore published in 1893. Having made arrangements with the proprietrix of the island, he began to prove the field by a series of bores, which were under the direction of Mr. Campbell as mining engineer, with the co-operation of Mr. C. B. Wedd, of His Majesty's Geological Survey. The results of these operations proved that the thickness of the ironstone was much greater than that indicated by Mr. Woodward, and that it covered a much larger area. By means of comparative vertical sections of the various bores he showed that the thickness of the deposit ranged from 6 to 17 feet. The quality varied somewhat, especially in the contents of lime. Generally speaking, it appeared that the percentage of lime increased towards the outside limits of the deposit, and the percentage of iron increased with the thickness. When compared with the Cleveland ore it was found that the Raasay stone contained more lime and phosphorus than the former, but rather less iron, and less silica and alumina. Reference was made to the faults shifting the outcrop of the band of ironstone, and to the relation of the intrusive masses of granophyre to the ore deposit. Mr. Thornycroft stated that the horizon of the ironstone underlay the whole of the northern part of Skye, and extended under the sea as far as the islands of Eigg and the Shiants, but it remained to be proved whether any ore in that position was ever formed outside the limited area of Raasay. He showed by sections of outcrops in Mull and the south-east of Skye that the ironstone had not been formed at the points visible, and that even if the iron-ore had been developed it would have been rendered unworkable by the intrusions of igneous rock.

IV.—Mineralogical Society.

March 11, 1913.—Professor H. L. Bowman, Vice-President, in the Chair.

W. Campbell Smith: The Mineral Collection of Thomas Pennant (1726–98). The collection, which has recently been presented to the British Museum by the Earl of Denbigh, is accompanied by three volumes of manuscript catalogue, written in 1757. The classification used in them is based with some modifications on Woodward's *Natural History of the Fossils of England*, published in 1729. Special mention is made of specimens presented by Borlase, Pontoppidan, and Da Costa, and the minerals from Flintshire were treated in some detail. Several specimens were described by Pennant in *A Tour in Wales*.—Arthur Russell: The Minerals and Mineral Localities of Montgomeryshire. Of the species described the more remarkable are aurichalcite, from Llanymynech Hill Mine, Llanymynech; harmotome in double twins, associated with barytes and witherite, from Cwm-orog Mine, Llangynog; hydrozincite, which forms a remarkable recent deposit on the sides of a level in the Van Mine, Llanidloes; pyromorphite from Aberdeunant Mine, Llanidloes, and Llanerch-yr-aur Mine, Llanbrynmair; witherite from Cwm-orog Mine, Llangynog, Gorn Mine, Pen-y-Gaer Mine, and Pen-y-Clyn Mine, Llanidloes, the crystals from the last being noteworthy on account of the almost entire suppression of the alternate faces of the pseudohexagonal prisms and pyramids.—Dr. G. F. Herbert Smith: A new Stereographic Protractor. The novelty consists of a curved ruler, made up of a combination of springs, which sensibly retains a circular curvature within the limits for which it is required. At the centre of the arc it is clamped to an arm, movable in a groove and carrying a scale, from which the azimuth of the corresponding great circle may be read off. The other edge of the protractor carries the usual tangent scales, from which the position of the compass to draw any circle up to the one corresponding to the great circle making an azimuth of 50° with the equatorial plane may be determined. The scales are based upon a radius of 10 cm.—L. J. Spencer: A (sixth) List of new Mineral Names.

CORRESPONDENCE.

THE AGE OF THE TORBAY RAISED BEACHES.

Sir,—If Mr. A. R. Hunt desires to be an effective critic and not a mere needless fault-finder, he should not base an argument on ancient history and ignore modern research. He thinks it "unfortunate" that in dealing with the evidence of raised beaches in a recent paper on "The Making of Torbay" I made no reference to the "voluminous literature" concerning them, and he writes as if he supposed there had been no change of opinion about them since the discussion which took place at the Geological Society in 1890.

Apparently he has not realized that the whole question of the age of the raised beaches in Devon and Cornwall has entered an entirely new phase since the discovery that the raised beach of Gower (in

South Wales) is older than the local glacial deposits. That discovery was made by R. H. Tiddeman in 1900, and was published in this Magazine for that year.[1] Moreover, in 1903 Messrs. Wright and Muff (Maufe) proved that the 12 to 15 ft. raised beach in the South of Ireland was also relatively pre-Glacial. These observers have shown that the descending succession in both countries is as follows:—

Upper head or local rubble.
Glacial deposits.
Lower head and cave earth.
Raised beach.

In Devon and Cornwall the succession is the same where most complete, but is usually without any glacial deposit, because the area was probably outside the limits of continuous ice even at the epoch of maximum glaciation. An accumulation has, however, been found above a raised beach in the Scilly Isles, which Mr. Barrow has not hesitated to describe as "a glacial deposit", and his final remarks regarding it are so much to the point that I may be excused for quoting them. He says: "The occurrence of this [deposit] is of the utmost importance, for not only can the old beach be now seen to be identical with that on the Cornish coast, but it is obviously contemporaneous with that described by Messrs. Wright & Muff (Maufe) occurring on the south coast of Ireland. It is also identical with that occurring in the South Wales area, for in both instances the head overlying the old beach is capped by a Glacial deposit. Thus, then, the old beaches in the Scilly Isles, in Cornwall, in South Wales, and in the South of Ireland are not only contemporaneous, but in addition are older than part of the Glacial Deposits" (*The Geology of the Isles of Scilly*, Mem. Geol. Survey, 1907). To this I need only add that Mr. Ussher has accepted the same date for the raised beaches near Plymouth (Mem. Geol. Survey, 1907). Naturally, therefore, in dealing with "The Making of Torbay" I thought it was sufficient to state that the age of the raised beaches in Devonshire had been so determined, and consequently I did not refer to the ancient history of the question.

Mr. Hunt, however, is bold enough to assert that "the intrinsic evidence of the Torbay beaches against an early glacial antiquity is very strong", and he indicates three lines of evidence, viz. those of flint implements, Molluscan fauna, and geographical position. He says that flints of recognized Neolithic age have occurred "at Hope's Nose in Torbay, in the Irish beaches, and in the Scotch beaches, all within the 25 foot level or terrace". Now, if by the words "at Hope's Nose" he means in the material of the beach we should like to have particulars of the find. The neolith obtained from the floor of Torbay proves nothing, neither do the finds in the raised beach of Antrim or in the Scotch 25 ft. beach, because it has been shown that the land-movements in the north were quite different from those in the south-west of the British area.

Mr. Hunt's second argument, based on the non-Arctic character of the Molluscan fauna, is specious but fallacious, because we have no standard of comparison within the areas of the English and Bristol

[1] Geol. Mag., 1900, pp. 441–3.

Channels, and we do not know how much the Molluscan assemblage in the Channel waters was affected by the cold of the Glacial Period. If I am right in believing that the Straits of Dover did not exist at the time when the raised beaches were formed, and that the Channel Sea was then a gulf opening westward, it is probable that the temperature of the water was never very much lowered, and that its fauna underwent very little change from early Pleistocene time to the present day.

With regard to Mr. Hunt's geographical facts, I quite fail to see their bearing or why a beach at Hope's Nose should "represent a very much later stage of coast erosion" than one at Portland Bill.

The matter stands thus: It is not a case of all the available evidence tending to show that I did not know what I was writing about; the geological facts are as I have stated above, and if Mr. Hunt declines to accept the inferences that other people have drawn from them, he will have to adduce much more definite and cogent reasons for his disbelief. It will certainly take all he can get out of "geography, conchology, physics, palæontology, archæology, anthropology, and micro-petrology" to upset the geological evidence!

In 1905 he had to admit that he had completely misunderstood one important particular in Messrs. Wright & Muff's (Maufe's) account of the Cork raised beach, and it now looks as if he had quite failed to realize its bearings in another direction.

A. J. Jukes-Browne.

P.S.—Since writing the above I have discovered what Mr. Hunt meant by his reference to a Neolithic flint "*at Hope's Nose*". It is recorded in one of his own papers,[1] and, as I suspected, it was not found in the beach itself. His words are: "I noticed a flint flake jutting out of a stratum of landwash at the top of the little cliff just east of the Hope's Nose beach. It was about two feet below the surface. With it there were three other fragments and two littorina shells. I sent the flake with one of the smaller pieces to Sir John Evans, K.C.B., who replied: 'Both the enclosed seem to be artificially made flakes probably of Neolithic date.' As there are some flints in the raised beach, it seems possible that these flakes were made on the spot." It is evident, therefore, that Mr. Hunt knew that the flint was only a flake, and that it did not occur in the material of the beach but in landwash above it; yet he blandly quotes its occurrence as an argument against the early Pleistocene age of the beach! It will be interesting to learn what explanation Mr. Hunt has to offer.

A. J. J.-B.

Westleigh, Ash Hill Road, Torquay.

AGE OF RAISED BEACHES.

Sir,—In an ingenious classification of the Raised Beaches and associated deposits of the South and West of England, Mr. H. Dewey (Geol. Mag., April, 1913, pp. 154–63) refers to similar beaches in the South of Ireland and brings them within his scheme. By a roundabout argument from their hypothetical relationship to the Thames

[1] Trans. Devon Assoc., vol. xxxvi, p. 475, 1905.

gravels, all these beaches are ranked in the scheme as newer than the Chalky Boulder-clay. But the only Infra-glacial beach that is known to occur within the region of the Chalky Boulder-clay, viz. that which is at times clearly exposed at Sewerby on the Yorkshire coast, is left entirely out of the reckoning. Thorough investigation of this beach by digging and borings in 1887–90 enabled me to show that it was older than the oldest ('Basement') Boulder-clay of the Yorkshire coast, which is at least as old as the Chalky Boulder-clay. Further, there can be no doubt that the Infra-glacial beaches of the South of Ireland, with which I am well acquainted, are of practically the same age as the Sewerby beach and stand in the same relationship to the glaciation. There seems every reason, also, for supposing that the Infra-glacial beaches of South Wales belong to the same period.

If Mr. Dewey be right in his correlation of the beaches of Devon and Cornwall with those of the South of Ireland, it would follow that they are older than the Chalky Boulder-clay, and not newer. But, in the absence of Boulder-clays south of the Bristol Channel, the correlation has still an element of uncertainty. Deposits of the character of 'Head' and 'Combe Rock' are unsatisfactory materials on which to base conclusions as to time-divisions of the Glacial period, since it is clear that rubbles of this type were being formed locally throughout the period in areas not covered by ice. In Yorkshire, though the chief masses occur beneath all the Boulder-clays, the rubbles are by no means confined to this horizon.

G. W. Lamplugh.

St. Albans.
April 13, 1913.

SEA-WATER AND CRITICAL TEMPERATURES.

Sir,—I certainly have never written a paper with the actual title referring to critical temperatures, but very much of my life has been spent in promulgating the view of the solubility of H^2O in fused silicates and laying down the fundamental principles of varying volcanic action based upon that as illustrated in fragmentary ejecta. Neither the critical temperature of water nor the spheroidal state has anything to do with the question, which, I have always maintained and repeat, depends on the critical temperature and pressure of solution of gaseous oxides (H^2O), etc., in fused liquid oxides and silicates.

Curiously enough, my views have never been much referred to in England, but are very generally accepted by Continental geologists, which, if we are to believe Mr. A. R. Hunt, means that English geologists read very little either the researches of their own countrymen or those of foreigners.

Nine of my papers in the list mentioned by Mr. Hunt refer to the subject under discussion, and I am now sending him a new list up to date of 161 papers, in which four others treat of the same question.

H. J. Johnston-Lavis.

Beaulieu-sur-Mer, France.
April 7, 1913.

OBITUARY.

FREDERICK JAMES MÖCKLER.

FREDERICK JAMES MÖCKLER died on March 12, 1913, aged 68. After a varied career, in which he became best known, perhaps, as an authority on Baxter Prints, Mr. Möckler was appointed curator of the Holburne Museum, Bath, a post which he was obliged to vacate some ten years ago on account of ill-health. Up to this time he had become acquainted with geological matters by handling material of Charles Moore's collecting, and by gathering and washing Faringdon Sponge Gravel for the use of E. C. Davey in his work on the fossils contained in that deposit.

It was not, however, until his employment for preparation-work in the Geological Department of the British Museum that he found scope for the exercise of the skill, amounting to genius, with which he resolved intractable sediments into a paste from which the particles of clay could be washed, and extracted thence organisms of extreme minuteness and delicacy; taking a genuine pleasure in the labour involved in picking over the residues grain by grain and separating the fossils from the inorganic particles. It is too soon to be possible to estimate the value to science of his labours; this will be fully appreciated by those who in future work out the Museum collections of Foraminifera, Polyzoa, Echinoderms, etc., with the material his skill has provided. But the untiring industry and humble conscientiousness with which he employed his talent declared his value to those who knew him. Science has lost in him a hard-working devotee, and his colleagues a genial and warm-hearted friend.

W. D. L.

MISCELLANEOUS.

GEOLOGICAL SURVEY OF INDIA.—The Secretary of State for India in Council notifies that one appointment to the Indian Geological Survey Department will be made in July next. A further vacancy is expected to occur in the year 1914.

INTERNATIONAL GEOLOGICAL CONGRESS.—Since the preliminary notice of the Session to be held in Toronto (given in the GEOLOGICAL MAGAZINE for September, 1912, p. 431), the dates of the meetings have been fixed to commence on Thursday, August 7, and to terminate on Thursday, August 14, 1913. Particulars have now been printed concerning the dates of excursions, the areas to be visited and the cost, accompanied by maps of the routes. (See second circular, to be obtained from the Secretary, Twelfth International Geological Congress, Victoria Memorial Museum, Ottawa, Canada.)

GEOLOGICAL SOCIETY OF LONDON, APRIL 9, 1913.—Mr. William Rupert Jones (son of the late Professor T. Rupert Jones, F.R.S.), who has filled the office of Assistant Librarian to the Geological Society, will retire on pension after forty years' service. He was a man with a remarkable knowledge and memory, and for many years had prepared a valuable list of additions to the Society's Library, which was regularly printed and circulated to the Fellows.

PROFESSOR JAMES GEIKIE, LL.D., D.C.L., F.R.S., ETC.

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ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

James Geikie, LL.D., D.C.L. (Dunelm.), F.R.S. L. & E., F.G.S.
Murchison Professor of Geology and Mineralogy and Dean of the Faculty of Science in the University of Edinburgh.

(WITH A PORTRAIT, PLATE IX.)

THE name of Geikie has become as familar to present-day geologists as those of Murchison, of Sedgwick, or of Lyell were to our immediate predecessors.

Notices and portraits of his elder brother, Sir Archibald Geikie, K.C.B., the President of the Royal Society, have already appeared in the Geological Magazine (see Vol. for 1890, Pl. II, pp. 49–51, and 1907, Pl. I, pp. 1–2); it is high time to present that of the younger brother, Professor James Geikie, who occupies the leading place in our science and in geography in Edinburgh and its University, and is known everywhere also by his published works, especially by his contributions to Glacial Geology.

James Geikie was born in Edinburgh August 23, 1839, and after being educated at the High School and the University of his native city, he entered the Geological Survey in 1861, and became a District Surveyor in 1869.

"In those early days," writes James Geikie, "when I joined the Geological Survey in Scotland, the Survey maps showed only the 'solid geology'; the loose superficial deposits known generally as 'drift' were entirely ignored. It was then decided that the 'drift' should henceforth be mapped, and thus my earliest years on the Survey were spent in re-surveying ground which had already been mapped so far as the solid geology was concerned, my work being confined to the insertion on the field-maps of the so-called 'drift' and peat. From the first, therefore, I became interested in our 'superficial formations', more especially in the Boulder-clay and the gravels and sands associated with it. My interest in these deposits, however, dates much further back—in fact, to my school days; so that I did not come to the Survey quite a greenhorn so far as the drifts were concerned.

"Later on, while mapping in the Southern Uplands, the peat-bogs, with their remains of trees, arrested my attention, and seemed to suggest that the explanation of the phenomena then in vogue was insufficient. Accordingly my holidays for a few years were spent in the Highlands and Outer Hebrides, for the purpose of increasing my knowledge, not only of peat, but of 'superficial formations' generally. Eventually I reached the conclusion that the phenomena of the peat bore witness to a succession of climatic changes, and my views were communicated to the Royal Society of Edinburgh in a paper 'On the Buried Forests and Peat-mosses of Scotland, and the changes of climate which they indicate'[1] (1866).

"I have, since then, considerably extended my acquaintance with the peat-bogs of Scotland and other lands, but have found no reason to change or modify the general conclusions I arrived at so long ago —conclusions which have been of late years strongly supported by Dr. Lewis, whose researches into the botanical history of the peat-mosses seem to me to mark a distinct advance in our knowledge of Pleistocene geology."

Dr. James Geikie's survey work in succeeding years lay chiefly in the Lowlands, and the bordering tracts of the Southern Uplands and Highlands. He had thus to map considerable areas of Silurian, Old Red Sandstone, and Carboniferous, together with large tracts of the associated igneous rocks. This 'solid geology' was sufficiently engrossing, but the glacial phenomena had certainly the greater fascination for him, and most of his holidays were devoted to the study of these phenomena either in this country or on the Continent. Having arrived at certain conclusions as to the climatic changes of Pleistocene times, he broached these views in the GEOLOGICAL MAGAZINE (1871–2) in a series of papers "On Changes of Climate during the Glacial Epoch". These papers formed the germ of James Geikie's *Great Ice Age*, issued in 1874, a second edition of which appeared three years later. His *Prehistoric Europe*, published in 1882, was really a supplement to that edition, while the third edition of the *Great Ice Age* (1894) embodied the further results obtained by assiduous study of the work done by others, and by the devotion of his holidays to research in this country and abroad.

Having been appointed (1882) to the Chair of Geology at Edinburgh, many new interests claimed his attention. His pupils having complained that the textbooks of geology then available were either too meagre or too elaborate for their purpose, Professor Geikie was induced to prepare an 'intermediate' textbook (*Outlines of Geology*) which was issued in 1884, a fourth edition being called for in 1903. He also set himself the task of improving the teaching of geography in schools. The kind of geography taught at that time and the textbooks in common use were dry and forbidding, and one had no difficulty in proving that such was the case. But James Geikie was only one of a number of ardent reformers, who in 1884 united to form a Scottish Geographical Society, which has succeeded beyond their utmost expectations, and has played no small part in effecting a complete revision of the mediaeval system of teaching geography in the Scottish schools, and in getting lectureships on the subject established in the universities. Dr. James Geikie was elected president in 1904, but after holding office for six years his constantly increasing work at the University compelled him to resign. On his retirement

[1] See GEOL. MAG., 1867, pp. 20–3, and Roy. Soc. Edinb., vol. xxiv, pt. ii, pp. 363–84.

the Council awarded him the gold medal of the Society, and invited him to have his portrait painted for the Society's hall. Professor James Geikie has for many years acted as Honorary Editor of the Society's organ, the *Scottish Geographical Magazine*, one of the best scientific journals extant.

His long connexion with the Royal Scottish Geographical Society induced him frequently to bring before his associates the importance of geology to all serious students of geographical science, and he summed up much of what he had advanced, in lectures and papers on the subject, in *Earth Sculpture or the Origin of Land Forms* (1898; last edition, 1909). Dr. Geikie has now in the press another similar work dealing with the borderland of geology and geography, but treating more especially of mountains. Meanwhile his interest in the history of the Ice Age has not abated. A few months ago he delivered a course of lectures in the University (under the 'Munro Foundation') on the "Antiquity of Man in Europe", in which the subject was discussed mainly from the geological point of view.

As a teacher Professor Geikie has of course endeavoured to give as wide a view of the stony science as one man can be expected to do. In the early 'eighties' he had to do all the work of his department single-handed, lecturing, demonstrating minerals, rocks, and fossils in the laboratory, as well as conducting field excursions. By and by, however, the department was strengthened by the appointment of able lecturers and assistants, and is now probably as well equipped as any similar school in the kingdom.

Students of applied science are, as might be expected, more keenly interested in practical work than in palæontological research or historical geology. From the first, therefore, Dr. Geikie endeavoured to meet their special requirements by devoting the summer term to the study of structural and field geology, and in 1898 he issued a textbook on the subject, which has gone through three editions (the last appearing in 1912), so that the book has apparently met a 'felt want'. Some years ago he began to form a lending and consulting 'class library' for the use of his students, which has now grown to respectable dimensions, thanks largely to generous contributions of geological literature from his brother, Sir Archibald Geikie. It contains upwards of 5,000 volumes, and many thousands of 'separates' from the scientific journals of this and other countries, besides a large collection of geological maps. This library (with the consent of his brother) has been presented to the University.

While busy enough with his duties as a teacher, Professor Geikie yet found time to take part in the administration of the University, having acted since 1891 as Convener of the Science Degrees Committee, and subsequently, after a Faculty of Science had been instituted by the Royal Commission in 1894, his colleagues did him the honour to elect him their Dean, an official position which he still holds. Since James Geikie joined the University in 1882 great changes have taken place. Not only have several new Chairs in the Faculty of Science been founded, but numerous additional lectureships have been instituted, and the whole system of teaching has been in a measure revolutionized. More especially is this noticeable in practical work—

the provision for which is constantly being increased by the enlargement of old laboratories and the building of new ones.

As a relief from professional work Professor Geikie has indulged, as most folk do, in hobbies. One of these has been the study of foreign literature—not wholly geological, as the issue of a volume of translations of Heine's Songs and Lyrics may serve to show. But not much idle time outside his professional duties has been allowed him, for he has been twice elected a President of a section of the British Association, that of Geography in Edinburgh and of Geology at Newcastle; while the United States carried him off to America to deliver a course of lectures at the Lowell Institute in Boston.

Professor James Geikie received the Brisbane Medal of the Royal Society of Edinburgh and also the Murchison Medal of the Geological Society of London in 1889. In presenting the latter Dr. W. T. Blanford, then President of the Geological Society, said: "The Council has awarded the Murchison Medal to Professor James Geikie in acknowledgment of his important contributions to the geology of North Britain, and especially of his investigation of glacial phenomena. His *Great Ice Age* contained a full, careful, and admirably written summary of the observations made up to 1874, and the interest excited by the work was proved by a second edition being required in 1877. Professor Geikie has besides published numerous papers, not the least important of which were two that appeared in the Society's Quarterly Journal containing his observations 'On the Glacial Phenomena of the Long Island or Outer Hebrides'."

A third edition of his *Great Ice Age* (largely rewritten) was published in 1894, and although so long a period had elapsed since the second edition appeared it speaks highly for the author's merits and charm as a writer that the book had lost none of its interest with geologists, nor with the reading public in general.

One of the most important advances made in glacial geology is afforded by the various evidences which have been brought to light which tend to establish the conclusion that prehistoric man was living and resident in Europe probably before the Great Ice Age, and certainly during the several mild interglacial periods which occurred prior to the final removal of the intense cold and the great permanent snow-fields of the Northern Hemisphere. In a valuable and exhaustive notice of Dr. James Geikie's work at the time (see Geol. Mag., 1895, pp. 29–38) Dr. Hinde observes: "Opinions may differ respecting some of the generalizations of the author, but all will agree on the value and importance of having the evidence on this subject stated in so clear and impartial a manner."

The warmest personal regard is entertained for Professor James Geikie, not only by his many friends and fellow-workers, but by the still larger number of those students who have come under the influence of his teaching and his writings during the past thirty years, and he will always be remembered as having added new impulse both to geography and geology, especially in the University of Edinburgh, where his name and services are not likely soon to be forgotten.

LIST OF SCIENTIFIC PUBLICATIONS BY PROFESSOR JAMES GEIKIE, F.R.S., ETC.

1866. "On the Metamorphic Lower Silurian Rocks of Carrick, Ayrshire": Quart. Journ. Geol. Soc., vol. xxii, pp. 513–34; Phil. Mag., vol. xxxii, pp. 154–5; GEOL. MAG., Vol. III, pp. 321–2.

"On the Metamorphic Origin of certain Granitoid Rocks and Granites in the Southern Uplands of Scotland": GEOL. MAG., Vol. III, pp. 529–34.

1867. "On the Buried Forests and Peat Mosses of Scotland, and the Changes of Climate which they indicate": Trans. Roy. Soc. Edinburgh, vol. xxiv, pp. 363–84; Proc. Roy. Soc. Edinburgh, vol. v, pp. 635–7; GEOL. MAG., Vol. IV, pp. 20–3.

"Hydrothermal Origin of certain Granites and Metamorphic Rocks": GEOL. MAG., Vol. IV, pp. 176–82.

"On the Metamorphic Origin of certain Granites, etc.": ibid., Vol. IV, pp. 287–8.

1868. "On Denudation in Scotland since Glacial times": Trans. Geol. Soc. Glasgow, vol. iii, pp. 54–74; ibid., Vol. V, pp. 19–25.

"Note on the discovery of *Bos primigenius* in the Lower Boulder-clay of Scotland": ibid., Vol. V, pp. 393–5, 535–6.

1869. "Additional Note on the discovery of *Bos primigenius* in the Lower Boulder-clay at Crofthead, near Glasgow": ibid., Vol. VI, pp. 73–5.

1870. "On the Age of the Stratified Deposits, with Mammalian Remains, at Crofthead, near Glasgow": ibid., Vol. VII, pp. 53–7, illus.

1871. "Carboniferous Formation of Scotland," remarks on Mr. Croll's letter: Trans. Geol. Soc. Glasgow, vol. iv, pp. 78–80; GEOL. MAG., Vol. VII, 1870, p. 298.

"On Changes of Climate during the Glacial Epoch": GEOL. MAG., Vol. VIII, pp. 545–53; Vol. IX, 1872, pp. 23–31, 61–9, 105–11, 164–70, 215–22, 254–65.

"The Carboniferous Formation of Scotland": Trans. North Eng. Inst. Min. Engin., vol. xx, pp. 131–57; Trans. Glasgow Inst. Engin., vol. xiv, pp. 5–31.

1872. "A. E. Törnebohm's Theory of the Origin of the Swedish Åsar": GEOL. MAG., Vol. IX, pp. 307–9, illus.

"On the Geological Position and Features of the Coal- and Ironstone-bearing Strata of the West of Scotland": Journ. Iron. and Steel Inst., vol. ii, pp. 8–24.

1873. "On the Theory of Seasonal Migrations during the Pleistocene Period": GEOL. MAG., Vol. X, pp. 49–54, illus.

"The Antiquity of Man in Britain" (a lecture): GEOL. MAG., Vol. X, pp. 175–9.

"On the Glacial Phenomena of the Long Island or Outer Hebrides": Quart. Journ. Geol. Soc., vol. xxix, pp. 532–45; GEOL. MAG., Vol. X, pp. 377–9.

1874. "Note on the occurrence of Erratics at higher levels than the Rock-masses from which they have been derived": Trans. Glasgow Geol. Soc., vol. iv, pp. 235–41; GEOL. MAG., Dec. II, Vol. I, pp. 566–7.

The Great Ice Age and its relation to the Antiquity of Man. pp. xxiii, 575, 17 pls., 8vo, London.

1875. *Geology.* (Chambers' Elementary Science Manuals.) pp. 96, illus., 8vo, London.

1876. "Origin of Lake Basins": GEOL. MAG., Dec. II, Vol. III, pp. 139–40.

"The Cheviot Hills": Good Words, vol. xvii, pp. 11–15, 82–6, 264–70, 331–7, illus.

Historical Geology. pp. vii, 94, 8vo, London and Edinburgh.

1877. "The Movement of the Soil-cap": Nature, vol. xv, pp. 397–8.

"The Antiquity of Man": ibid., vol. xvi, pp. 141–2.

Letter to Mr. J. Gunn on the Glacial Beds of the East of England, *Norfolk Chronicle*, February 17.

1877. *The Great Ice Age and its relation to the Antiquity of Man.* 2nd ed., pp. xxvii, 624, 19 pls., 8vo, London.

1878. "On the Glacial Phenomena of the Long Island or Outer Hebrides" (2nd paper): Quart. Journ. Geol. Soc., vol. xxxiv, pp. 819–67, illus.

"On the Preservation of Deposits of Incoherent Materials under Till or Boulder-clay": Geol. Mag., Dec. II, Vol. V, pp. 73–9, 287–8.

(With A. C. Ramsay) "On the Geology of Gibraltar": Quart. Journ. Geol. Soc., vol. xxxiv, pp. 505–39.

1880. "Discovery of an Ancient Canoe in the Old Alluvium of the Tay, at Perth": Scottish Naturalist, vol. v, pp. 1–7.

"Changes of Climate in Post-Glacial times": ibid., pp. 193–203.

1881. "Natural Rubbish Heaps": Proc. Perthshire Sci. Soc., vol. i, pp. 3–5.

"The Geological History of Perthshire" (Presidential Address, March 3, 1881): ibid., pp. 17–21.

"The Age of the Igneous Rocks of Iceland": Nature, vol. xxiv, pp. 605–6.

Prehistoric Europe: a Geological Sketch. pp. xviii, 592, 2 pls., 3 maps, 8vo, London.

1882. "Notes on the Geology of Colonsay and Oronsay": Trans. Glasgow Geol. Soc., vol. vi, pp. 157–64.

"Climatic and Geographical Changes in Post-Glacial times": Proc. Perthshire Sci. Soc., vol. i, pp. 47–50.

"The Study of Natural Science" (Presidential Address): ibid., pp. 65–70.

"The Intercrossing of Erratics in Glacial Deposits": Scottish Naturalist, vol. vi, pp. 193–200, 241–54.

"On the Geology of the Færöe Islands": Trans. Roy. Soc. Edinburgh, vol. xxx, pp. 217–69, 4 pls.; Proc. Roy. Soc. Edinburgh, vol. x, pp. 495–501; Geol. Mag., Dec. II, Vol. IX, pp. 278–9.

"The Aims and Method of Geological Inquiry" (Inaugural Lecture, October 27, University of Edinburgh): Nature, vol. xxvii, pp. 44–6, 64–7, 8vo, Edinburgh.

1884. "Note on the occurrence of Drifted Trees in Beds of Sand and Gravel at Musselburgh": Proc. Roy. Soc. Edinburgh, vol. xii, pp. 745–55.

1885. "The Physical Features of Scotland": Scottish Geogr. Mag., vol. i, pp. 26–41, map.

"Leading Physical Features of Scotland": Ordnance Gazetteer of Scotland, vol. iii (Appendix), No. 2, 8vo, Edinburgh.

"List of Hill Forts, Intrenched Camps, etc., in Roxburghshire on the Scotch side of the Cheviots": Proc. Berwick Nat. Club, vol. x, pp. 139–48.

1886. "Mountains: their Origin, Growth, and Decay": Scottish Geogr. Mag., vol. ii, pp. 145–62.

"The Geographical Evolution of Europe": ibid., pp. 193–207.

"Note on Sand-dunes of the Western Islands": ibid., p. 474.

"The Natural History of Kinnoull Hill." II. Geology: Proc. Perthshire Sci. Soc., vol. i, pp. 235–7.

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1887. "Geography and Geology": Scottish Geogr. Mag., vol. iii, pp. 398–407, map.

"Geology and Petrology of St. Abb's Head": Proc. Roy. Soc. Edinburgh, vol. xiv, pp. 177–93, illus.

Songs and Lyrics by Heinrich Heine and other German Poets. 8vo.

1888. *Outlines of Geology.* 2nd ed., 8vo, London.

1890. "The Evolution of Climate": Scottish Geogr. Mag., vol. vi, pp. 59–78, 2 maps.

"Glacial Geology" (Presidential Address to Section C, Geology, of the British Association): Rep. Brit. Assoc. for 1889, pp. 551–64; Geol. Mag., Dec. III, Vol. VI, pp. 461–77.

1891. "On the Scientific Results of Dr. Nansen's Expedition." I. Geology: Scottish Geogr. Mag., vol. vii, pp. 79–86.

1892. "On the Glacial Succession in Europe": Trans. Roy. Soc. Edinburgh, vol. xxxvii, pp. 127–49.
"Supposed Causes of the Glacial Period" (an address): Trans. Edinburgh Geol. Soc., vol. vi, pp. 209–30.
"The late Sir Andrew Crombie Ramsay, LL.D., F.R.S., etc.": ibid., vol. vi, pp. 233–40, portrait.
Address to the Geographical Section of the British Association, Edinburgh, 1892: Scottish Geogr. Mag., vol. vii, pp. 457–79, map.
"Recent Researches in Pleistocene Climate and Geography" (Abstract of a Lecture to the Royal Scottish Geographical Society, May 18, 1892): ibid., vol. viii, pp. 357–62.
1893. "Geographical Development of Coastlines" (Presidential Address to Section E, Geography, of the British Association): Rep. Brit. Assoc. for 1892, pp. 794–810.
Fragments of Earth Lore, Sketches and Addresses, Geological and Geographical: pp. vi, 428, 6 pls., 8vo, Edinburgh.
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II.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the May Number, p. 199.*)

(PLATE VIII.)

Avicularia of what I have called the *Lesueuri*-type are not confined to *Membranipora*. There are at least two species provided with them which come nearer to *Semieschara*.

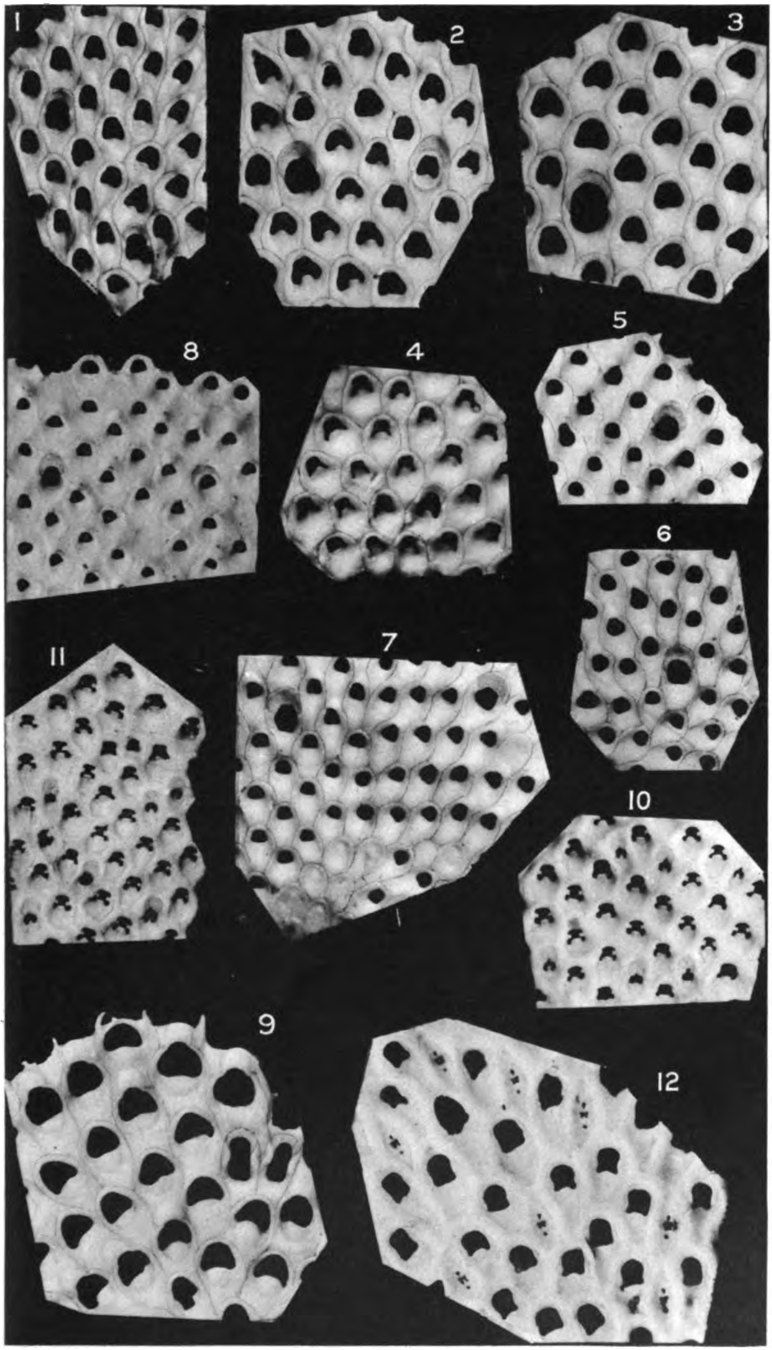
Semieschara labiatula, sp. nov. (Pl. VIII, Figs. 1–4.)

Zoarium always adherent.

Zoœcia subpyriform, with separate side walls which are broad and pass gradually down into the front wall; apertures large and subtriangular, with the apex flattened owing to the development of a slight internal front wall, fairly straight sides with a tendency to bulge inwards towards the top and a lower lip always more or less convex with an upturned tip which catches the light and is very useful for rapid recognition; these convexities are most marked in the later forms and may be so pronounced as to make the aperture definitely trifoliate (Fig. 4).

Oœcia abundant, narrow helmet-shaped swellings of the foot of the succeeding zoœcium.

Avicularia abundant and typical; aperture broadly elliptical, but with a distinct tendency to assimilate itself in general outline to the zoœcial aperture (especially in the lower lip, which may be strongly convex), the lower section nearly or quite equal in size to the upper; the infold of the side wall sudden, with a concave edge; avicularia of a modified form looking as if a small zoœcium had been set into the aperture of a normal avicularium occur very sparingly (Fig. 2).



R. M. Brydone, Photo. *Bemrose, Collo.*

Chalk Polyzoa.

The species occurs rarely and of small size in the upper subzone of the zone of *O. pilula*, and becomes fairly common in the restricted zone of *A. quadratus* but remains small; at Trimingham it is abundant and distinctly larger, occasionally attaining a very considerable size. I have no specimens from intermediate horizons.

The avicularia enable it to be distinguished at once from such species as *Cellepora Villiersi*, D'Orb.,[1] or the earlier figures of *Eschara Delarueana*, D'Orb.,[2] to which zoœcially it bears some resemblance.

SEMIESCHARA OCCLUSA, sp. nov. (Pl. VIII, Figs. 5–8.)

Zoarium always adherent.

Zoœcia long and pyriform, with separate side walls; apertures more or less semicircular, with strongly rounded corners and slightly flattened at the head by the development of a tiny internal front wall; imperforate lids which completely seal up the aperture are preserved here and there all over the zoarium and abundantly among the early zoœcia.

Oœcia abundant, narrow helmet-shaped swellings of the foot of the succeeding zoœcium.

Avicularia apparently very similar to those of *S. labiatula*, but with the infold of the side wall in such low relief that it is very difficult to make out its details (the definiteness of the illustrations has largely accrued in the process of reproduction); apertures normally enlarged copies of the zoœcial apertures, but with a distinct tendency to rectilinear outlines, which sometimes goes so far as to turn them into rude hexagons; modified avicularia similar to those of *S. labiatula*, but much less conspicuous, are fairly common.

The species is common at Trimingham, especially in the lowest beds exposed there, and probably therefore has a further range downwards, and as this range does not extend to the Weybourne horizon it may possibly be of assistance in identifying Chalk intermediate between the Trimingham and Weybourne horizons.

SEMIESCHARA MUNDESLEIENSIS, mihi.[3] (Pl. VIII, Fig. 9.)

The original figure of this species was inaccurate, and as it is near enough to *S. labiatula* for comparison I give a photograph of the type. It will be seen that the avicularia are constructed on the same general plan of infolded side walls as the *Lesueuri*-type, but cannot be included in the latter, as they are not conspicuously larger than the zoœcia. I have found rather primitive specimens of this species very occasionally in the *mucronata*-chalk of the Isle of Wight and Hants.

SEMIESCHARA CANUI, mihi.[3] (Pl. VIII, Figs. 10, 11.)

ESCHARA ROWEI, mihi.[3] (Pl. VIII, Fig. 12.)

I take this opportunity of supplementing the diagrammatic original figures of these species by photographs of specimens lending themselves to photography more kindly than the types.

In the case of *S. Canui*, Fig. 10 shows that this species possessed oœcia in the shape of large, flat, rather inconspicuous swellings,

[1] Pal. Franç., tom. v, p. 407, pl. 605, figs. 8, 9.
[2] Tom. cit., p. 105, pl. 602, figs. 6–8.
[3] GEOL. MAG., 1906, pp. 289–300.

a perfect one and one unroofed being visible. They are of rare occurrence. The avicularian aperture has a semicircular upper lip with unbroken curve when perfect, as shown by the original figure and Fig. 11, but the regularity of the notches shown in Fig. 10 suggests a median line of weakness, perhaps indicating that the species started with a notch there, the filling up of which was not yet fully consolidated.

In the case of *E. Rowei* it is clear that the outline of the avicularian aperture was misrepresented in the original figure, and that it has a straight lower lip and diverging sides and a convex upper lip, and that the lower lip bears a long slender denticle.

EXPLANATION OF PLATE VIII.

(All figures × 12 diams.)

FIG. 1. *Semieschara labiatula.* Zone (restricted) of *A. quadratus*, Upham, Hants.
FIGS. 2, 3. *S. labiatula.* Trimingham. Normal specimens.
FIG. 4. ,, ,, Trimingham. Small form with trifoliate apertures.
FIGS. 5–8. *S. occlusa.* Trimingham.
FIG. 9. *S. Mundesleiensis.* Trimingham. Type-specimen.
FIGS. 10, 11. *S. Canui.* Trimingham.
FIG. 12. *Eschara Rowei.* Trimingham.

III.—ON THE RIGIDITY OF THE EARTH, AND ON COLONEL BURRARD'S THEORY OF THE HIMALAYAS.

By the Rev. O. FISHER, M.A., F.G.S.

IN the April number of this Magazine a review appeared of Colonel Burrard's memoir[1] on the origin of the Himalaya Mountains. The writer, Sir T. H. Holland, in it refers to a paper of mine originally published in the Phil. Mag.,[2] and subsequently in an amended form as Appendix No. 1, 1905, Indian Survey Papers, professional vol. xviii. I shall be glad to make a few remarks upon the subject. After duly crediting me with having partially anticipated the results now obtained by the Survey, by calculating the deflection of the plumb-line in North India which would follow from my theory of mountain compensation by a 'root' extending to a depth of about 29 miles, the reviewer continues—"The variations now observed are, however, more violent than those expected by Mr. Fisher, for the northerly deflections of the plumb-line decrease to zero at a distance of about 15 instead of over 60 miles from the visible foot of the hills." I would reply that I have not calculated the deflection at 15 miles, and it is not safe to guess *a priori* what it would be. The numerical calculation for a given distance is tedious, and I could not now undertake it.[3]

Though Sir T. H. Holland appears to admit that my theory (or rather Airy's) of mountain roots goes some way to account for the observed deflection, he nevertheless adds that it does not "march", like Colonel Burrard's, "with the growing belief in a solid earth."

[1] Survey of India, professional paper No. 12, Calcutta, 1912.
[2] Phil. Mag., January 7, 1904.
[3] In the Phil. Mag., p. 24, in the formula for the attraction of the plateau, there is a misprint. After the first bracket insert x.

This statement possibly refers to Professor Hecker's observations on the bodily tides of the earth. I understand the word 'solid' as opposed to 'fluid', not as equivalent to 'rigid'. Is it not possible that there may be a liquid substratum to the earth's crust, and the earth may nevertheless be rigid with respect to the external disturbing forces of the attraction of the moon and sun as evidenced by tides? By way of illustration, we are quite unconscious of the rotation of the earth on which we stand. But if we could observe the earth with a telescope from the moon, the effect of rotation would be very marked by the rapid passage of objects near our equator across the field of view. Is it not possible that the earth's rotation may impart to it a 'gyroscopic' *quasi* rigidity, which may enable it to withstand the deforming influence of external forces, although at the same time forces internal to the earth will be unaffected by it.

Professor Perry, in his little book on spinning-tops, illustrates how "rapid motion gives a peculiar *quasi* rigidity to flexible and even to fluid things. Here," says he, "is a disk of quite thin paper; and when I set it in rapid rotation you observe that it resists the force exerted by the blow of my fist as if it were a disk of steel. Hear how it resounds when I strike it with a stick. Where has its flexibility gone?"

In the highly interesting and instructive paper which Sir G. H. Darwin read at the Geodetic Conference of 1909, giving an account of Hecker's observations of the tidal deformation of the earth, he reproduced Hecker's curve, which represents the rigidity both in north and south, and east and west directions. The radius of this curve is proportional to the rigidity, and shows in a remarkable manner that the rigidity is much greater in the east and west direction than in the north and south. And in the discussion that followed Darwin said that he "considered as worthy of consideration Professor Hecker's explanation of the remarkable absence of symmetry in the path of the vertical" (that is, the difference of rigidity in different directions, Hecker's explanation depending upon the geographical situation of Potsdam), "but he suggested an alternative possibility. The curve was much compressed in the north and south direction, showing that the earth has much greater rigidity east and west than north and south. It is possible to explain this to some extent by the earth's rotation. Lord Kelvin introduced the idea of 'gyroscopic', that is of greater rigidity east and west due to rotation. Whether this is a sufficient explanation cannot be said, because no one has succeeded in solving completely the gravitation problem of a rotating elastic globe";[1] nor yet, I believe, of a partially liquid one. Although it may be that rotation imparts a greater rigidity in the equatorial direction, yet Professor Perry's experiment quoted above shows that there is great rigidity imparted in the axial direction also. If rotation is competent to impart the needful excess of rigidity, it may be pertinent to ask, why not the whole of it?

I do not remember ever to have seen changes of level accounted for on the hypothesis of a solid earth. There also appears to be some

[1] *Nature*, vol. lxxxi, p. 427, October 7, 1909.

reason for believing that alterations in the force of gravity are even now going on at Dehra Dun in India, which would indicate internal movements of mass incompatible with solidity.[1]

Colonel Burrard's theory, of a rift in the sub-crust along the area of low density skirting the mountain range, will no doubt receive the consideration which the high position of its author demands for it; but it is obvious that there are difficulties. He appears to believe that the sub-crust beneath the mountains contracted upon itself, and in being shortened laterally became thickened vertically, and rose up into a mountain range, leaving a rift where it parted from the adjacent sub-crust. If it was in a state of tension, it is conceivable that a rift might have been formed, and that it might have contracted upon itself until the tension was relieved. During this part of the process it would have decreased in volume and become more dense. Then it seems to be supposed that the process of lateral contraction continued, and, contrary to what might be expected, it became less dense. A decrease of mass below corresponded to the protrusion of the mountains above. The material remaining below thus became less dense than the mountains which it pushed up, and *that* in spite of the pressure. Thus partial isostacy would result. These movements being supposed to have gone on in a sub-crust, any rift formed by them would appear to have been more likely to open from below, and to have been filled with heavy material rather than with sediment from the surface. Rifts have been abundantly formed among the older rocks, but they are never empty, but filled with some intrusive material or mineral veins, usually of a denser character than the country rock. An empty rift would be an anomaly.

In any theory of a mountain range allowance must be made for the enormous amount of material which has been denuded from it; in the case of the Himalayas, the Sewalik range, the alluvium of all the Indo-Gangetic plain, besides what has been carried out to sea by rivers. Elevation in compensation of this waste is continually going on, and it is probable that it is this which is the cause of the frequent earthquakes that occur in the district.

IV.—The Minerals of the Barrington Bone-bed.

By R. H. Rastall, M.A., F.G.S.

ONE of the most important and most interesting features of the geology of the Cambridge district is the deposit at Barrington, so widely known for its richness in mammalian remains. This bone-bed has been described many times, and the literature is large. Most of the descriptions, however, confine themselves chiefly to the organic contents, mentioning briefly the character of the larger stones and pebbles, and saying little or nothing about the nature of the finer matrix in which these are embedded.

The author has been for some time past engaged in the study of the mineralogical composition of the sands and gravels of Pleistocene

[1] See Colonel Burrard's paper, Phil. Trans., ser. A, vol. ccv, 1905. Also *Nature*, vol. xci, p. 143, 1905.

and Recent age in this district, with a view to ascertaining whether the character and possible derivation of the smaller mineral grains might throw any light on the correlation of these puzzling deposits. Some of the results have been already published,[1] while other groups are still under investigation. Since the Barrington Bed is so widely known, and so peculiar in character, it seemed advisable to accord it separate treatment.

The earliest detailed description of the lithological character of the bone-bed appears to be that given by the Rev. O. Fisher in 1879[2]; it is as follows:—

"The materials of which the bone-bearing deposit consists are peculiar. The matrix is a grey sand with a slight admixture of clay. The pebbles consist of flint in subangular pieces of no great size, sometimes ochreous, sometimes grey, sometimes black. These are not rounded, but have their surfaces worn, polished, and the angles rubbed off. There are rolled lumps of Chalk-marl and a considerable admixture of 'coprolites', as might be expected, seeing that the coprolite-bed is abraded by the deposit itself. The remaining pebbles are well-rounded pieces of crystalline rocks, consisting of quartz, quartzite, syenite, jasper, and trap. These old rocks contribute a large part of the pebbles, so that the material cannot be called a flint-gravel, in that it appears to consist of the least destructible parts of the Boulder-clay, mixed with materials from the Chalk-marl and Greensand.

"There appear to be very few remnants of the Oolitic rocks among the pebbles, except a few fragments of *Gryphæa*. The pebbles are, for the most part, not at all decomposed, as those are which one now picks up in the neighbouring ploughed fields, and the glacial scratches are well preserved."

The foregoing description was penned at a time when the facilities for a thorough examination were greater than at present exist. The section is described as extending for 70 yards from north to south, and workings were then in active operation. It only remains to add, what is not perhaps there made sufficiently clear, that many of the so-called 'pebbles' are large stones, weighing as much as 14 or 16 lb., and that large, well-rounded boulders of hard white Chalk are common. It is, however, mainly with the finer material of the beds that we are here concerned, and the characters and origin of the larger constituents, though a topic of great interest, cannot be further discussed.[3]

Since the deposit shows a good deal of variation from top to bottom, several samples were collected from different parts, and of these three are here more particularly described.

1. This specimen was obtained about two feet from the top of the bed. It may be described as a white chalky gravel and sand,

[1] "The Mineral Composition of some Cambridgeshire Sands and Gravels": Proc. Camb. Phil. Soc., vol. xvii, pp. 132–43, 1913.

[2] "On a Mammaliferous Deposit at Barrington, near Cambridge": Quart. Journ. Geol. Soc., vol. xxxv, pp. 670–7, 1879.

[3] For the most recent description see Hughes, "Excursion to Cambridge and Barrington": Proc. Geol. Assoc., vol. xxii, pp. 268–78, 1911.

containing a good many small flints and pebbles of hard Chalk. After passing through a sieve to remove the larger fragments, the material was washed with water. After prolonged washing the white chalky mud was removed and the residue was found to be a clean white sand, consisting of approximately equal parts of colourless quartz and white calcareous matter, chiefly Chalk in small rounded grains. There were also abundant white prismatic structures, apparently including both prisms from the shells of *Inoceramus* and spines of Echinoids. Red, brown and black grains constitute only a small proportion of the whole, while glauconite is also to be seen occasionally.

With dilute acid the effervescence was naturally very copious, and the insoluble residue was a notably white sand. The heavy constituents of the sand were then roughly concentrated by panning, and finally separated in bromoform in the usual way.

The principal minerals noted in the ultimate residue were as follows: garnet, abundant, in angular, subangular and rounded grains, often very strange shapes, either colourless, pink, or pale brown; tourmaline, common, in round grains or less commonly idiomorphic crystals, generally brown; kyanite, rather abundant, in angular fragments or rounded grains; staurolite, in rounded grains, a rather unusual circumstance; muscovite, in small quantity, chiefly in minute flakes. Other less common transparent minerals were green and blue hornblende, deep-red rutile and yellowish-green epidote. Among the opaque constituents the most abundant were pale-brown rounded grains of indeterminable nature, together with a smaller quantity of magnetite. The significance of this assemblage of minerals and their probable source will be discussed in the concluding section.

2. This was a small sample collected from near the middle of the bed. In general character it was much like the last, and the residue of white sand was almost identical in appearance. The chief minerals found in the rather scanty heavy residue from bromoform were as follows: garnet occurs in grains rather larger than the rest, colourless, pink or brown, and of a great variety of shapes, often very angular, though some are distinctly rounded. Hornblende is common, chiefly of the ordinary green variety, though some grains have a blue tinge. Staurolite and kyanite are rather abundant in fairly large grains, although tourmaline is not very common. Among other transparent constituents rutile and epidote are the most notable, zircon being quite rare. Muscovite also occurs in small flat flakes. When examined by reflected light magnetite is seen to be very common, and there are also opaque white and brown grains. The general form of the mineral grains shows much variation, some being conspicuously rounded while others are just as notably angular. It is probable that the very round grains have been obtained in that state from some older formation.

3. This specimen is of special interest, since it represents the lowest part of the deposit, the actual bed in which the bones are found. It is a white marly substance, soft and rather plastic when fresh and moist, but when dried setting into a hard mass. This, however, falls

to pieces readily when placed in water. The preparation of the specimen was difficult, since very prolonged washing is needed to get rid of the fine white chalky mud. When this had been removed there was left a mass of fine gravel and sand with flints and Chalk pebbles and many shells. The latter were mostly in a very fragmentary condition, though some were unbroken. A large proportion of the residue consisted of very fine sand, and in this minute grains of brilliant green glauconite were visible. After concentration by panning, the heavy minerals were found to be present only in small amount, and the grains were also less in size than in the other specimens. The only abundant mineral is white mica, in thin flakes of varying size. Besides this there were a few crystals and broken fragments of garnet, together with rounded grains of hornblende and a very few zircons. One grain of rutile was seen and one flake of kyanite; magnetite is not very abundant. The general assemblage of minerals in this sample is much the same as the others, the chief difference being the much greater abundance of muscovite. This latter fact is probably to be correlated with the preponderance of finely divided material.

In connexion with the foregoing descriptions several points present themselves for discussion. In the first place the chalky material which is so abundant clearly belongs to two different types: the fine chalky mud is undoubtedly derived from the underlying Chalk Marl which forms the bed-rock of the deposit. But the pebbles and grains of Chalk, of rounded form, which are such a characteristic feature, are for the most part much harder than the Chalk of the Cambridge district, and must have been transported by ice from more northern localities. The very brilliant green grains of glauconite must have been derived from the Cambridge Greensand, which underlies the bone-bearing deposit over part of its extent. Grains of glauconite derived from the Neocomian show a duller shade of green of a quite different tint, easy to recognize, though difficult to define in words.

The general assemblage of heavy minerals here identified is, on the whole, similar to that found in the other Pleistocene and Recent gravels of the Cambridge district. There is, however, one notable exception, namely, the occurrence at Barrington of abundant white mica, a mineral which is notably absent from other localities, although it is fairly common in some fine sands and marls near Newmarket, and is abundant in a sand on the summit of the Gogmagog Hills. The sporadic distribution of mica in these deposits is a curious circumstance for which no plausible explanation has yet been found.[1] Of the other minerals the most interesting are tourmaline, kyanite and staurolite, which, as is shown in the paper previously cited, have probably been derived from the Neocomian rocks. The garnet, hornblende, zircon, rutile and others, are believed to have been for the most part obtained from the far-travelled constituents of the Glacial Drift, which has undoubtedly provided a great proportion also of the larger elements composing the superficial deposits of this district.

[1] See Proc. Camb. Phil. Soc., vol. xvii, p. 142, 1913.

V.—The Limbs of *Lystrosaurus*.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology, University College, London.

Lystrosaurus, Cope = *Ptychognathus*, Owen (*non* Stimpson), has long been known from isolated but often perfectly preserved skulls. Quite recently the reception of a magnificent skeleton by the Albany Museum, Grahamstown, enabled me to give a restoration of the animal. In this drawing the hand and foot were drawn from incomplete non-associated remains. Whilst travelling in South Africa, with the aid of a grant from the Percy Sladen Trustees, I collected on the farm Klip-kuil a fragmentary skeleton of *Lystrosaurus*, much of which was so rotten that it could not be preserved, but which included a complete left fore-limb. This was developed by myself and was found to lie in its natural position with the digits very

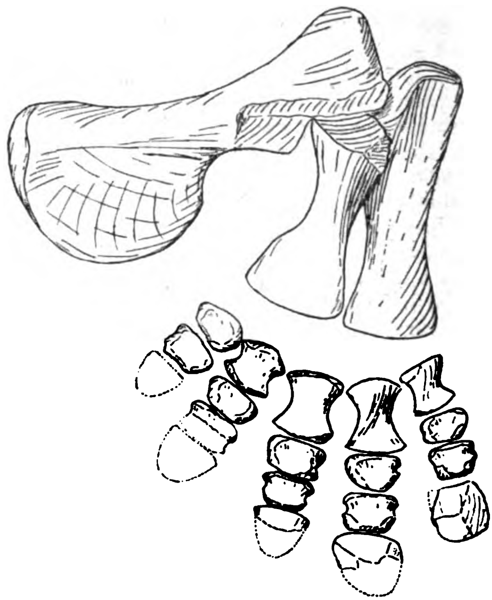


Fig. 1. Left forearm of *Lystrosaurus* sp., Klip-kuil, District Albert, Cape Colony. Viewed from the front. × ½. The lower end of the humerus is broken so as to show the articular face of the upper end of the radius.

strongly flexed, except that the metacarpals were slightly separated laterally. It is represented in Text-fig. 1, with the humerus, radius, and ulna in the position in which they were found, and with the fingers extended. The humerus is not very well preserved, but agrees exactly with the excellent example figured by Owen, *Catalogue of South African Fossil Reptiles*. It is of the usual Anomodont type, with a very powerful deltoid crest extending half-way down the shaft, and a much expanded lower end with a large entepicondyle. There is a large entepicondylar foramen, but no ectepicondylar perforation. The bones of the forearm agree with those of the Albany Museum skeleton. The radius is a short bone, with a narrow, nearly circular, shaft, expanded at the top to a head, which is provided with an articular face divided by a ridge into two parts, the anterior articulating with a face on the front of the humerus, the other jointing with that on the head of the ulna to articulate with the end of that bone. The lower end is much expanded laterally. The ulna has a stout head of triangular section, its antero-internal face articulates with the head of the radius, and its articular face for the humerus is continuous with one of those of the other bone. There is no produced olecranon process, but the bone has obviously had a cartilaginous expansion in this region. The shaft is thin and the lower end laterally widened.

As in all Anomodonts, the forearm was carried at right angles to the humerus and had probably only a very limited range of movement. Looked at from the front, the head of the radius lies before a good deal of the head of the ulna, so that there is some crossing. Study of well-preserved shoulder-girdles shows that the humerus was carried generally at right angles to the body, as in most primitive reptiles and the living Monotremes. In this individual there is no ossification in the carpus, and its length is uncertain. All five metacarpals are preserved; the first is a rounded nodule of bone, from the second to

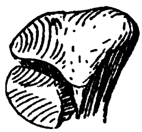


FIG. 2. The upper ends of the radius and ulna of the specimen represented in Fig. 1. × ½.

the fifth there is a perceptible shaft, and the bones increase in length to the fourth, which, as is usual in reptiles, is the longest.

The first phalange of each digit is a curious nodule of bone, which in longitudinal section is triangular, the dorsal surface being flat and the two articular surfaces nearly meeting below. The second phalange of the first digit is not preserved; those of the other fingers are flat, and have a trace of a shaft in a notch on either edge. Their articular faces are parallel. The third phalanges of the third, fourth, and fifth digits are flat, very thin, and spreading. Taken as a whole the hand is an aquatic modification of the ordinary Anomodont type; the chief modifications are the excessive breadth, the flattening of all the bones, and the great expansion of the terminal phalanges. The most curious feature is the triangular section of the first phalange, which allows of very great flexion of the digits; the same feature occurs in *Kannemeyeria* and in Monotremes, to the foot of which that of Anomodonts offers many striking resemblances, as Owen, Seeley, and Broom have already recognized.

Amongst the series of South African fossils presented to the British Museum by Mr. David Draper, the well-known Johannesburg geologist, is an extremely well-preserved fragment of *Lystrosaurus* from Harrismith, O.F.S. This shows the lower end of the tibia and fibula, the tarsus, and some metatarsals and phalanges. The tibia is not at all compressed, the lower articular face being almost circular. The fibula is a much more slender bone than the tibia; its narrow shaft, however, flares out somewhat to the distal articular face, which is flat. There are two tarsals, nearly spherical masses of very spongy bone, with flattened dorsal and ventral surfaces; these two bones enclose the usual foramen, and are so situated in relation to the fibula as to show that that bone articulated with both of them. In this specimen and in another quite similar one, also in the British Museum, the large articular face of the tibia does not face any bone, and it seems quite certain that a large part of it only articulated with a cartilage during the life of the animal. The arrangement is, in fact, extraordinarily like that of *Limnoscelis* as figured by Williston (*Amer. Journ. Sci.*, vol. xxxi, p. 396). The most reasonable explanation seems to be that the two bones are the fibulare and intermedium, the tibiale being unossified. This interpretation is supported by the very curious fact that in Plesiosaurians, where the

FIG. 3. The lower ends of the tibia and fibula, the complete tarsus, three metacarpals, and some phalanges of the left side of *Lystrosaurus*. From Harrismith, O.F.S. × ½.

intermedium is always separated from the tibiale, that bone does not ossify in *P. Hawkinsi*, and is only represented by a very small nodule of bone in *P. rugosus*.

The great amount of cartilage remaining unossified about both *Limnoscelis* and *Lystrosaurus* is rather remarkable, as the Seals and Sirenia, which seem to offer the best comparison from the point of view of probable habits, are well ossified.

The three metacarpals preserved are slender, long-shafted bones, little compressed, and their proximal ends are very close to the two ossified tarsals, so that the cartilaginous distal tarsals were probably much reduced. The few phalanges preserved are similar to those of the hand.

One of the incomplete feet of *Lystrosaurus* in Grahamstown shows four phalanges on two neighbouring digits, so that in the foot this type exceeded the normal mammalian number of 2, 3, 3, 3, 3 of phalanges which occur, as shown by the specimen just described, in the hand.

VI.—On the Occurrence of the Lynx in North Wales and Derbyshire.

By J. Wilfrid Jackson, F.G.S., Manchester Museum.

On looking over a miscellaneous collection of animal bones from a cave in North Wales, sent to me for identification by Mr. John H. Morris, of West Bromwich, I was pleased to discover the remains of the lynx, and as our knowledge of the occurrences of this animal in the British Isles is so scanty, it seems to me to be of some interest to record the present discovery.

Hitherto remains of this creature have only been recorded from a few places in this country. It was first discovered about 1866 in a fissure, termed the Yew-tree Cave, in Pleasley Vale, on the borders of Nottinghamshire and Derbyshire, the remains consisting of a right ramus of a lower jaw and the hinder part of a skull.[1] Fourteen years later two bones, a humerus and a metatarsal, were met with in a fissure in Teesdale, Durham, and were described by Mr. William Davies.[2] In 1897 its remains were met with in fair quantity, by Mr. W. Storrs Fox, in a cave in Cales Dale, Derbyshire,[3] while the most recent record appears to be that of the Rev. E. H. Mullins, who gives it in his list of animals found in Langwith Cave, near Mansfield.[4]

The North Wales cave, the site of the present discovery, is situated some two and a quarter miles to the south-east of Prestatyn and is known as Gop, or Newmarket, Cave. It is the same cave from which Professor Dawkins obtained the remains of the hyæna, bison, reindeer, woolly rhinoceros, etc., as well as domestic animals, pottery, and human bones, indicating that the cave had been used at a later period both for habitation and burial purposes.[5]

Displacement of stalactitic matter behind the area explored by Professor Dawkins revealed the presence of a continuation of the cave in the form of low tunnel from which other tunnels strike off to the right and left. The one on the left leads back to the cliff where an entrance has at some remote period been artificially closed by a barrier of limestone.

The discovery of these further passages led to explorations being made by Mr. John H. Morris, Lieut.-Colonel T. A. Glenn, and others, in 1912, with the result that several other remains, both animal and human, were met with in digging into the cave-floor in different places.

Amongst the animal bones sent to me for examination I have been able to identify those of the bison, bear, badger, fox, wolf, roe, stag, horse, hare, ox, sheep, pig, domestic fowl, coot, etc., as well as the lynx, as mentioned above.

The bison and bear are each represented by one bone only, in the former case by a left magnum, and in the latter by an imperfect left humerus wanting both extremities. As to the species of the

[1] W. Boyd Dawkins, *Brit. Pleist. Mam.* (Pal. Soc.), i, p. 172, 1869.
[2] Wm. Davies, Geol. Mag., 1880, p. 346.
[3] W. Storrs Fox, Proc. Zool. Soc., i, p. 65, 1906.
[4] Journ. Derbyshire Archæol. and Nat. Hist. Soc., vol. xxxv, p. 150, 1913.
[5] Dawkins, Archæol. Journ., lviii, pp. 322–41, 1901.

latter it is difficult to decide; the bone agrees with a corresponding bone of the brown bear (*Ursus arctos*) in the Manchester Museum, and in all probability belongs to that species.

With the exception of the lynx and wolf, all the other animals are well represented by several parts of their skeletons. Most of these, however, appear to have been met with in association with the human remains found in the cave, and without doubt belong to a later period.

The lynx is represented by the right ramus of the lower jaw containing only the carnassial tooth, the others being represented by their sockets. The ramus is almost complete, wanting only the angle and part of the articular condyle; the alveolar border is more curved than the inferior, and the jaw is thickened anteriorly. There is a small convexity of the inferior border owing to the ramal process being slightly developed.

Compared with the examples from Pleasley and Cales Dale, the Gop jaw is somewhat smaller, but appears to belong to the same species, viz. the Northern Lynx, *Felis lynx* (*borealis*).

The following table of measurements (in inches and tenths) shows the correspondence of the Gop jaw with those of Cales Dale, Pleasley, and a Northern Lynx in the British Museum (B.M. 1230A), these last three being taken from Mr. W. Storrs Fox's paper (op. cit., p. 68), and Professor Dawkins' *British Pleistocene Mammalia*.

Measurements of Right Ramus of Lower Jaw.

	F. lynx, Gop.	*F. lynx*, Cales Dale.	*F. lynx*, Pleasley.	*F. lynx* (*borealis*), B.M. 1230A
Maximum length	3·65(?)	—	4·2	4·0
Maximum height	1·66	—	1·68	1·8
Circumference behind m. 1	2·2	2·37	2·2	2·0
,, before p.m. 3	2·25	2·14[1]	2·4	2·0
Diastema	·2	—	·3	·3
Length of inferior border	2·7+	—	3·3+	3·5
Length of molar series	1·5	—	1·54	1·55
Antero-posterior extent of m. 1	·62	·68	·65	·65
Antero-transverse ,,	·25	·25	·26	·26
Postero-transverse ,,	·23	·26	·24	·26
Height of crown of m. 1	·33	·46	·35	·39
Symphysial length	1·1	—	1·25	1·1
,, breadth	·5	—	·5	·55

Unfortunately the geological age of the various remains in this cave cannot be determined with absolute accuracy, as, owing to the excavations of badgers, foxes, etc., it was impossible to be sure of the relative positions of some of the bones. The discovery, therefore, of the lynx throws no fresh light upon the question of the period at which this animal inhabited this country. That it lived side by side with the other fierce carnivores seems the most reasonable suggestion, for, as pointed out by Professor Dawkins (*Brit. Pleist. Mam.*), the

[1] Taken behind socket of canine, as p.m. 3 is entirely lacking.

carnivore in question must have crossed over into Britain when this country formed part of the mainland of Europe; for it is impossible to suppose that it could have invaded our Island from France or Germany during prehistoric times.

But what we should like to know more about is the period of its extinction in Britain. Like the wild cat it may have lingered in the wilder districts much later, say, than the lion, almost down to the historic period, for it appears to have only recently become extinct in France, a specimen being killed in the Haute Loire in the year 1822, while a second was killed in Württemburg in 1846.

In conclusion, I wish to thank Dr. C. W. Andrews for kindly confirming the identification of the lynx and several other forms. I am also indebted to Mr. J. H. Morris for allowing me to describe this specimen.

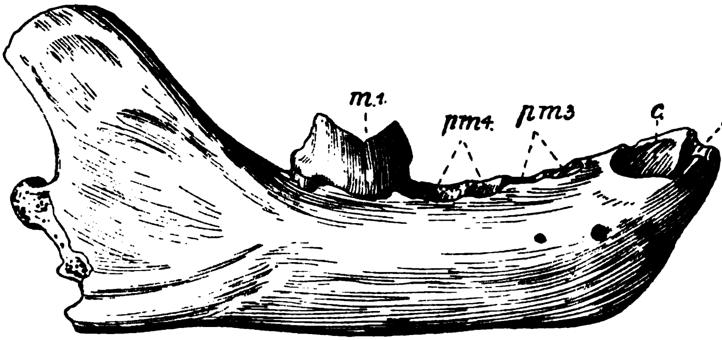


FIG. 1. Right ramus of the lower jaw of Lynx. Gop Cave, near Prestatyn, North Wales. Nat. size. *m. 1* = true molar; *p.m. 4* = socket for fourth premolar; *p.m. 3* = socket for third premolar; *c.* = socket for canine; *i.* = socket for third incisor.

Since writing the above note I have discovered a fragmentary right superior maxilla of a lynx in the Manchester Museum collections, the specimen being labelled as coming from Cales Dale, Derbyshire. It appears to have been in the Museum for some years and may possibly have been obtained during one of the explorations of Cales Dale Cave previous to that of Mr. Storrs Fox in 1897.

The specimen is of some interest on account of the entire absence of the anterior premolar tubercular tooth, with no trace of any alveolus. This feature appears to be one of the characters constituting MM. Croizet et Jobert's species, *Felis brevirostris*, remains of which were found in one of the Cresswell Crag caves (Robin Hood) and described by Dr. R. Laing in the Report of the British Association for 1889 (pp. 582–4).

The Cales Dale specimen being so fragmentary does not lend itself to detailed measurements, but one or two can be given. The total length of the canine is 1·75 inches, while the height of the crown is ·75 in.; between the canine and p.m. 3 there is a diastema of ·35 in., owing to the missing anterior premolar; p.m. 3 measures ·45 in. in length and ·25 in. in breadth, while the crown is ·35 in. in height.

The crown of the canine is supported by a strong sub-cylindrical fang; the inner surface of the crown is somewhat flattened and bounded anteriorly and posteriorly by two sharp ridges passing from the apex to the base. The external surface of the crown is strongly convex and traversed by two short but fairly deep furrows near the apex—the inner surface is without furrows.

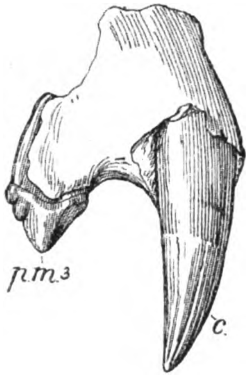


FIG. 2. Fragment of right upper maxilla of Lynx. Cales Dale Cave, Derbyshire. Nat. size. *p.m. 3* = third premolar; *c.* = canine. Note entire absence of second premolar!

The crown of p.m. 3 consists of a stout primary cone inclined inwards, as in *F. spelæa*, but is without the usual secondary cusp on the antero-internal aspect; the secondary and accessory cusps are present behind, and divided from each other by clefts. A sharp ridge traverses the tops of these cusps to the apex of the primary cone, thence it continues as a blunt ridge down the antero-internal slope. The cutting lobes are, therefore, all on the posterior slope of the tooth.

The absence of p.m. 2 is remarkable and suggests reference to the form known as *F. brevirostris*, but as this tooth is frequently entirely wanting in small specimens of the lion, tiger, and *F. spelæa*,[1] it may not be of any great significance.

VII.—Submerged River-valleys.

By R. M. Deeley, F.G.S., Memb. Inst. C.E.

Bathymetric surveys have revealed much that is very interesting concerning the ocean floors, not only as regards the deeper portions, but also as concerns the continental shelves. Hull has constructed charts of the North Atlantic and shown that many of the shallower areas are of such a form as to suggest that they were originally portions of existing river-basins, and that the submerged valleys may be traced along the sea bottoms to depths of more than a thousand feet round the present continents. Similar

[1] *Brit. Pleist. Mam.* (Pal. Soc.), i, p. 69, 1868.

submerged troughs have also been noted along the margin of the Asiatic continent. Two such well-marked channels occur in the ocean at the mouths of the Indus and Ganges. Indeed, the phenomenon would seem to be one common to all the continental shelves.

Attempts have been made by some to explain the existence of these apparently submerged valleys by assuming that the set of the ocean currents tends to erode the ocean floor and produce depressions which simulate river-valleys in the adjoining seas. This explanation, however, does not seem to have met with much favour; for it assumes the existence of ocean currents which have not been observed, and also assumes that such currents, if they exist, could erode the ocean floor at very great depths. By others it has been suggested that these continental sea-shelf prolongations of existing valleys are recent land areas which have been submerged. If such depressions were local such an assumption might be made with some certainty, but as they are a common feature all over the earth the questions naturally arise—Where, if they are due to a rise in the sea-level, has the water come from, and how, if they are due to a sinking of the land, comes it about that this has affected all the continental shelves at the same time?

The difficulty, however, disappears if we regard these continental shelf depressions as of all ages. The present river-valleys and river-basins are certainly, in the main, of very great age. Indeed, we should treat the seaward prolongations of valleys as proving submergence, just as we treat beds containing marine fossils which are now found at great heights above the sea as proving emergence resulting from the rise of the land. It is not now suggested that elevated marine beds indicate that the sea once stood at that level. The volume of water in the oceans must be regarded as a fixed quantity, the apparent changes in the level of the sea being the result *mainly* of oscillations of the earth's crust. According to this view these submerged valleys may not be of any particular age. Indeed, some of them may be of Palæozoic age. The actual ages can only be ascertained by a study of the deposits on their floors and margins, just as the ages of the deposits forming the land surfaces are ascertained by the nature of the fossil remains they contain.

VIII.—Note on South African Cretaceous Dinosaurs.

By E. H. L. S.

THE result of the Tendaguru expedition to German East Africa has been the discovery by Drs. W. Janensch and E. Hennig of some forty Dinosaurs, ranging in size from forms larger than *Diplodocus* to ones as small as a pointer dog; these finds may be extended since Dr. H. Reck has proceeded to the locality with the intention of digging for a further year. In a paper by Dr. Hennig on the possible extension of the Dinosaur deposits[1] this author calls attention to the discovery by the late Dr. W. G. Atherstone of Dinosaur remains in the Wood Bed (Lower Cretaceous) of Bushman's River. In his

[1] Sitz. Ges. naturf. Freunde, Berlin, 1912, pp. 493–7.

description, published in the *Eastern Province Magazine*, Grahamstown, 1857, Dr. Atherstone states that a large part of the skeleton as well as the skull was discovered, but the only parts so far described are two skulls named by Owen *Anthodon serrarius*. Very little is known of this form, and Zittel places it in the Pareiasauridæ as a Karroo reptile. Dr. R. Broom described another Dinosaur from the same beds at Despatch, near Port Elizabeth, under the name *Algoasaurus Bauri*.[1] Messrs. Rogers and Schwarz mention Dinosaur bones as occurring in the sandy beds along the Bezuidenhouts River in Uitenhage,[2] and some detached bones and teeth from these beds are exhibited in the Albany Museum, Grahamstown. All these remains are of comparatively small animals for Dinosaurs. In the recent Whitsuntide holidays Professor E. H. L. Schwarz took his students to the Bushman's River, and in Dr. Atherstone's "Iguanodon Hoek" they discovered the femur of one of the gigantic forms. The bone was broken, and only the two ends were recovered; the shaft, having only slender walls, had splintered up, and for the most part had disappeared, but when whole the bone was some five feet in length. A further find of a smaller form was made a little lower down, but the bones were very much decomposed and no attempt was made to dig them out. A properly equipped expedition will be sent to the place by the Albany Museum, and there is every prospect of obtaining one or more of these gigantic skeletons. Close to the spot is the famous Alum Cave, whence the mineral Bushmanite, a variety of Apjohnite, is obtained.

REVIEWS.

I.—Geological Survey of Scotland Memoir.

The Geology of Upper Strathspey, Gaick, and the Forest of Atholl. By George Barrow, F.G.S., Lionel W. Hinxman, B.A., F.R.S.E., and E. H. Cunningham Craig, B.A., with contributions by H. Kynaston, B.A. 8vo; pp. vi, 116, with 2 text-illustrations and 4 plates. Edinburgh: printed for His Majesty's Stationery Office, 1913. Price 2*s*.

THE country described in this memoir is included in the Scottish colour-printed one-inch map, Sheet 64 (price 2*s*. 6*d*.). It is a mountainous area drained by the rivers Spey, Dee, Tilt, and Garry, and it extends over portions of Inverness, Perth, Aberdeen, and a small tract of Banff in the north-east.

The Highland schists known as the Moine Series occupy the larger portion of the ground, from the Spey Valley, with the favourite resort of Kingussie, over the western and east-central region, including Glenfeshie Forest, Loch an t-Seilich, Gaick Forest, and the northern part of the Forest of Atholl. This is a somewhat monotonous tract of tableland, rising 2,500 to 2,750 feet, intersected by deep trench-like valleys and with mountains that seldom reach 3,000 feet.

[1] Geol. Mag., Dec. V, Vol. I, pp. 445–7, Figs. 1–3, 1904.
[2] Ann. Rep. Geol. Comm. for 1900, Cape Town, 1901, p. 13.

To the south-east is the complex area bordering the Tilt Valley, where the Perthshire Series of Highland schists is divided by Mr. Barrow into (1) Central Highland quartzite, (2) Honestones or Parallel-banded group, (3) Little limestone (locally the Tremolite limestone), (4) Dark schist, (5) Main limestone, and (6) Calc-flintas. The order of succession, ascending or descending, is not known. The quartzite forms mountains, two of which rise to over 3,000 feet, and Mr. Barrow points out that they are "built up by the repeated folding on itself of one bed of sandstone, which cannot have been originally more than 30 feet thick, if so much. In the Benin à Ghlo Mountains the limbs of the folds are absolutely isoclinal, and attain an amplitude of at least 2,300 feet, with a persistent dip of 60 degrees to the south-east. This structure is exactly that produced by the shutting up of the bellows of a concertina, and may be conveniently called 'concertina structure'".

Associated with the Highland schists are certain intrusions of basic igneous rock, epidiorite and hornblende-schist, and intrusions of the older granites.

A large tract of newer granite forms the Cairngorm Mountains, with Ben Macdui 4,296 feet in elevation, and portions of Mar Forest in the north-east, being a part of "the largest area of continuous high mountain ground in Britain"; while to the south, and west of the Glen Tilt area with which it is associated, is another tract of the granite, which rises to 3,304 feet in Beinn Dearg and 2,992 feet in Beinn Bhreac. As remarked by Mr. Barrow, "a great historical interest attaches to this intrusion, for it was to the veins proceeding from it, so admirably seen in the Tilt at the old stone bridge above the Forest Lodge, that Hutton so confidently appealed in support of the view of the intrusive nature of granite, which he so ably expounded in his *Theory of the Earth.*"

In the eastern part of the Cairngorm Mountains the granite, as described by Mr. Cunningham Craig, contains vertical or highly inclined veins of fine-grained material, which is "the chief source of the Cairngorm stones, which were at one time so much sought after". Various other igneous rocks, including diorites, lamprophyres, felsites, and quartz-porphyries, are described, and their influence on the scenery is pointed out.

In glancing at the map while perusing the memoir, it becomes evident how strenuous a task must have been the mapping of the rocks, the physical exertion alone being excessively arduous, and the localities where quarters could be obtained being few and lonesome. No doubt the attractions of fishing may have served to relieve the monotony, and rest the individual when stress of weather prohibited field-work.

Glacial deposits and peat extend over large areas, together with fluvio-glacial gravels (in the Spey Valley) and alluvium. It is remarked by Mr. Hinxman that "the effect of glacial action in modifying surface features is principally shown by the softened outlines produced by distribution of glacial detritus over the irregularities of the pre-glacial surface". Interesting observations are recorded on the scenery, the river-systems, and the changes they have undergone. The valley of Glen Tilt, of which an illustration is given in the frontispiece, is a pre-Glacial gorge 1,000 feet deep in places, and of extreme straightness owing to erosion along the shatter-belt of a fault. During the period of maximum glaciation, ice-sheets, one from the far west and one that took a westerly or south-westerly direction from the Cairngorm range, became confluent for a time. Valley glaciers were formed later on. The effects of erosion during the Glacial epoch are best seen in the higher glens and corries, and in over-deepened valleys with bordering hanging valleys and waterfalls. A good view is given of a high-level corrie-tarn, Loch Coire an Lochain, which is held up at an elevation of 3,250 feet by the terminal moraine of the corrie-glacier.

There is no chapter on economic deposits, but there appear to be none of much importance. Mention is made in the course of the memoir of the honestones and the cairngorms that were formerly worked, also of the peat. It is noted by Mr. Barrow that "a feature of the Bynack peat is the great number of roots of fir-trees met with, which are seen protruding from the wasting edges of the peat along the stream banks. In this ground there are three tiers of these fir-roots rising one above the other; when dried they form a valuable fuel, as they burn like a candle, and in old days were actually used for that purpose". Splinters have similarly been used in Sutherlandshire.

A bibliography forms the concluding part of the memoir, and it may be added that the map is clearly colour-printed and in all respects excellent.

II.—Geology of Egypt.

The Geography and Geology of South-Eastern Egypt. By J. Ball, Ph.D., D.Sc. Survey Department, Cairo, Egypt. Government Press, Cairo, 1912. 4to; pp. xii + 394, with 27 plates and 62 text-illustrations. Price 40 piastres.

IT rarely happens that circumstances admit of a desert region being accurately mapped and studied in detail, since the economic importance of such parts of the world is usually very small. It is therefore fortunate for geologists and geographers that the demand for prospecting and mining licences in the south-eastern desert of Egypt, which arose about eight years ago, led to a survey which otherwise might never have been undertaken. A considerable number of points had to be located with such accuracy that the boundaries of any concessions which might be granted could be defined without the possibility of any ambiguity; at the same time as good a topographical and a geological survey were required as could be provided under the prevailing conditions. In the course of three winter seasons (1905–8), representing twenty-two months of field-work, Dr. Ball completed this work, and the results are presented in the volume before us. It is a notable contribution to the geology of North Africa, and one which presents many points of interest. All existing maps of the area were on small scales and of very inferior accuracy, so that a new survey covering about 22,000 miles has been carried out, and the results are given in an orographical map on the scale of 1:750,000 and in a geologically coloured map on the same scale. These two taken together give an excellent picture of a region of which hitherto little has been known. As a result of this state of things a large part of this volume is taken up by detailed descriptions of the drainage systems, the hills and mountains, and the water supplies, which are mainly topographical but which contain a certain amount of geological information. A most valuable chapter treats of the special methods adopted in the survey to meet the conditions which prevailed, and this will repay careful study by all who may have to prepare their maps in hilly regions which are not largely timbered. Triangulation was extensively employed, and a very free use of vertical angular measurements furnished a very reliable representation of the relief of the region.

Sedimentary deposits are scantily represented by the coral reefs and raised beaches along the coast, the gypsum beds which occur on part of the coast, and the Nubian Sandstone which covers a considerable area in the western portion of the region. Besides these, alluvial deposits and accumulations of rock waste in the valleys and on the plains at the foot of the hills cover wide tracts, but igneous and metamorphic types of rocks form the surface over by far the larger part of this desert.

The igneous rocks fall broadly into two main divisions, one of an acid type represented by a granite rich in felspar, and the other of a basic type having gabbro for its representative. A few ultra-acid and ultra-basic rocks occur, while an intermediate division is also represented, but rocks of the granite and gabbro types predominate. The former occur largely as forming the higher mountains and dominant peaks, while the basic rocks form the lower hill-country.

Full descriptions are given of typical specimens from various localities, together with the special characters which microscopical examination brings to light. Volcanic rocks are comparatively scarce, and nothing like the wide occurrence which Dr. Hume has recorded in the north-eastern portion of this desert has been found by Dr. Ball in the south-eastern. Basic rocks predominate somewhat in the southern portion of this region, and rocks of the ultra-basic group, usually altered to serpentine, cover as much as 200 square miles of the desert.

Gneisses and schists cover very large areas, and the former constitutes some of the boldest scenery of the precipitous hills of the central portion of the range. Many ancient mining sites occur in this area, where the quartz veins have been worked for gold in the past, but in many cases they do not pay sufficiently to be worked under modern conditions. Besides the maps already mentioned, several plans on larger scales usefully supplement the text, while photographs of several mountain-summits and types of country illustrate the weathering of the rocks. The whole question of erosion and the development of the surface relief, for which Dr. Ball must have ample material, promises to be most interesting, and will doubtless be dealt with in due course. As it is, the present volume contains a very valuable account of a region offering many problems, for whose solution Dr. Ball has furnished important material.

A final chapter treats of the tectonic structure of the district and the possibility of the Eocene rocks and the Nubian Sandstone having had formerly a wider extension. In summarizing the past history of this part of Africa Dr. Ball suggests that the Red Sea depression originated between Upper Cretaceous and Oligocene times, and was increased in area by a sinking of the crust along its margin in Miocene times. The main drainage systems were, he thinks, initiated as early as the Oligocene period.

H. G. L.

III.—Geological Survey: Mineral Products of India.

A REVIEW of the mineral production of India during the year 1911 is given by the Director, Mr. H. H. Hayden, in pt. iii of vol. xlii of the *Records*. The method of classification is the same as that used previously, and we learn that the collecting of returns becomes more precise every year. A comparison of the total value of the minerals produced in 1910 and in 1911 shows an insignificant fall of half per cent. At the same time such important minerals as coal, gold, petroleum, and wolfram show a steady rise, the drop in the value of the total production being due to the curtailment in the output of manganese. The paper gives full tabular details of the mineral concessions granted during the year, and these show a good increase, this being due chiefly to the quest for wolfram in Lower Burma and for manganese in the Central Provinces.

The second paper in this part is by Dr. L. L. Fermor on "The Systematic Position of the Kodurite Series, especially with reference to the Quantitative Classification". Some three years ago Dr. Fermor described the series of rocks of which kodurite (composed of orthoclase felspar, a manganese garnet and apatite) is the type, but at the time he was unable to investigate its classificatory position. He has lately been able to investigate the matter, and has taken the opportunity of testing the methods of quantitative classification as set forth by Messrs. Cross, Iddings, Pirsson, and Washington. Dr. Fermor finds that these methods lack elasticity; on the other hand, he found no difficulty in fitting the kodurites in the classification adopted by Hatch, in which the Kotakarra kodurite may be called a mangan-shonkinite. One of the difficulties in the American system is the inability to deal with high MnO. The author finds the 'norm' distinctly useful, however, and promises further discussion on this point when his investigations are complete.

IV.—Indian Desert Salt Deposits.

IN an interesting and highly important article on "The Origin of Desert Salt Deposits" Professor Sir Thomas H. Holland gives the results of his researches, aided by chemical analyses made by Dr. W. A. K. Christie, on the salt deposits of the Rajputana Desert (Proc. Liverpool Geol. Soc., xi, p. 227, 1912). It is pointed out that "Throughout the whole desert the subsoil water is highly charged with sodium chloride, which is raised for the purpose of manufacturing salt at various places. The largest of the lakes is at Sambhar, which, when filled with water at the end of the rainy season, covers, according to the season, from 70 to 80 square miles, and with the latter area may reach a depth of only four feet in the centre of the lake". Since 1869 this lake has been "one of the principal sources of salt in Northern India, the output being on an average about 140,000 tons a year". About ten years ago it was thought that the resources of the lake might be diminishing, but investigations and borings made by the Geological Survey of India demonstrated "the occurrence of something like 54 million tons of salt in the uppermost 12 feet of silt", and anxiety was relieved.

After discussing various theories propounded with regard to the origin of the salt, Sir Thomas Holland points out that during the hot dry season large areas of the Rann of Cutch become covered with an incrustation of salt. During the same period, from April to June, dry, hot, and strong winds and gales blow from the south-west and carry away great quantities of the dry and powdery salt to the Rajputana Desert. When the rains set in the salt at and near the surface is carried in solution by the floods into the hollows which become temporary lakes, and after the rainy season is over there will be areas of concentrated brine, with or without complete evaporation, during a cold dry period. These conditions are succeeded by the hot season and by further supplies of salt-dust carried by the south-west winds. Observations and experiments carried on by Sir Thomas Holland and Dr. Christie have led them to conclude that at least 200,000 tons of salt are thus annually distributed over the Rajputana Desert.

Attention is drawn to the observations of the late J. Lomas on the features common to the Trias and to modern desert formations. Among these explanation is given of the occurrence of pseudomorphs of rock-salt and of the nature of the so-called red marls, which consist largely of very fine particles of quartz dust. It is noted that the silt of Sambhar consists locally of large accumulations of the finest mud of a deep-black colour, due to the presence of ferrous sulphide, and it is suggested that the red colour of the mudstones or so-called marls of the Trias are equivalent deposits, their colour being due to the subsequent oxidation of the iron-salt.

With respect to the bearing of wind-borne salt on estimates of geological time, the author supports the conclusions of Professor Joly and others concerning "the relative unimportance of such cyclic sodium in calculations regarding the rate of accumulation of salt in the ocean".

V.—Geological Survey of Western Australia.

IN Bulletin No. 45, 1912, Mr. H. W. B. Talbot deals with parts of "The North Coolgardie and East Murchison Goldfields", giving the results of a series of traverses made in company with Mr. C. S. Honman, the Topographical Surveyor. The report is illustrated by a geological sketch-map of the country around Lake Barlee (scale

4 miles to one inch), showing areas of granite, ferruginous quartz-schist, quartz reefs, and greenstones with undifferentiated metamorphic rocks (Auriferous Series). Some photographic views and sections are inserted in the text, and appended is a petrographical description of some rocks from the vicinity of Lake Giles, by Mr. R. A. Farquharson. The rocks comprise gabbro, epidiorite, amphibolite, etc.

Bulletin No. 46, 1912, contains "A General Description of the Northern Portion of the Yilgarn Goldfield and the Southern Portion of the North Coolgardie Goldfield", by Mr. Harry P. Woodward. The object of the report is to indicate those tracts of country to which prospectors are advised to devote attention, and also those to be avoided, such as certain large sand-covered granite areas. Information is given on the evidence to be gathered from the soils and surface features, and also on the important matter of water-supply.

Bulletin No. 50, 1912, is on "The Geology and Mineral Industry of Western Australia", by Mr. A. Gibb Maitland and Mr. A. Montgomery. This is a useful guide, giving a summary of what is known of the geological formations, and of the economic geology, included under the headings of gold, copper, lead, tin, tantalum, iron, coal, salt, phosphate deposits, and artesian water. Information is also given with regard to the mining and occupation of mineral lands.

VI.—Geological Survey of New Zealand.

"THE Geology of the Waihi-Tairua Subdivision, Hauraki Division" forms the subject of Bulletin No. 15 (new series), 4to, Wellington, 1912. The area, which is described by Dr. J. M. Bell (late Director) and Mr. Colin Fraser, constitutes part of the eastern coast of Hauraki, in the northern portion of the North Island of New Zealand.

With the exception of the superficial deposits the country is formed of a complex of volcanic rocks, which probably were extruded through a foundation of Jurassic or older rocks, none of which are exposed in the Waihi-Tairua Subdivision. The volcanic rocks form a series (1) of andesitic and dacitic lavas and breccias of Upper Eocene or Miocene age, (2) of somewhat similar but more fragmental materials and more glassy lavas of Miocene age, and (3) of rocks mostly rhyolitic, with dacitic tuffs, breccias, and lavas of Pliocene and perhaps later times. Many dykes of andesite and dacite pervade the lavas, and the rocks have been much altered by hydrothermal action. Among the rhyolites a brecciated flow-rock locally known as 'Wilsonite' is used as building-stone and road-metal.

Mining is the principal industry in the region, and the metalliferous areas of gold with silver appear to be limited to the Eocene and Miocene series (1 and 2). In the Waihi Gold-field the more productive part is within a large intrusion of dacite. Gold-bearing quartz-veins occur in the volcanic rocks. The first discovery of gold in New Zealand was made in 1852 in the Coromandel Subdivision, to the north-west of the area now described. At Waihi the yield in 1910 was a little more than one million pounds worth of bullion.

Particulars are given of the methods of mining and treatment of ores, of the mineral veins and the conditions of the mineralized areas, the sinter deposits, and the underground waters, and there are detailed descriptions of the different mining areas and claims.

The greater portion of the area of volcanic rocks is hilly and mountainous, the highest elevation being that of Mount Kaitarakihi, 2,740 feet, and at one time the ground was covered by primeval forests, which have been much reduced by fires. The lower grounds are partly volcanic, as in the case of the Waihi plain, but are formed mostly by the fluviatile and estuarine deposits, the flood-plains constituting the chief arable lands. The coast is formed of precipitous cliffs with bays bordered by blown sands.

The volume is well illustrated by 10 plates of photographic views, 10 text-figures, and 18 geological and topographic maps, plans, and sections.

VII.—Textbook of Petrology. Vol. II. The Petrology of the Sedimentary Rocks. By F. H. Hatch and R. H. Rastall. With an appendix on the systematic examination of loose detrital sediments, by T. Crook. pp. xiv + 425, with 60 figures in the text. London: George Allen & Co., 1913. Price 7*s.* 6*d.* net.

THIS work is stated to be the second volume of a textbook on petrology, but the first has not yet appeared, unless it be Dr. Hatch's earlier book on petrology issued some few years ago by another publisher, and no mention is made of it in the preface. The present volume is concerned with the processes and changes through which sedimentary rocks have passed before they attained to the position and form in which they are found to-day. The subject falls naturally into two parts, the one dealing with the nature of the deposition and the other with the after metamorphic changes. That is the course followed by the authors in the present book, the second part being about half as long again as the first.

In the first chapter of the first part the authors discuss deposition in general, and proceed in the remaining three to enter more in detail into the three groups of fragmental, chemical, and organic deposits, into which sedimentary rocks may be grouped. Many of the deposits are of extreme interest and importance. For instance, the salt deposits are extensively worked, and those at Stassfurt in particular formed the subject of the classical researches by Van't Hoff and his pupils. Again, the nitrate deposits in Chili become increasingly necessary for agriculture, and their origin still remains a mystery, no completely satisfactory theory having yet been put forward. The coal deposits are, of course, of primary importance as the principal source of heat and power; the vexed question of their origin is touched upon.

The second part is devoted to the metamorphic changes that have taken place in the rocks after they were deposited, and successive chapters deal with metamorphism in general, cementation and metasomatism, contact metamorphism, regional metamorphism, and weathering. The particular subject applies to a considerable extent to rocks in general, and would better have formed part of a general introduction to the whole work, if there is in truth to be a volume on the igneous rocks. The authors might have availed themselves of the space left free to discuss the classification of the sedimentary rocks.

Mr. Crook, of the Technological Department of the Imperial Institute, contributes an extremely valuable appendix on the systematic examination of loose detrital sediments. He has had some years of experience of the investigation of such material, and the hints that he is able to give will be welcomed by those with less experience and skill who may be faced with a similar task. Mr. Crook is a strong advocate of magnetic separation. An ordinary horseshoe magnet has, of course, long found a place in mineralogical laboratories for separating purposes in the analyses of rocks and meteorites, but by the use of an electromagnet he has elaborated a ready and useful method, which in conjunction with heavy liquids very speedily resolves detritus into its component mineral parts. The ordinary optical methods are referred to, and the general characters of the detrital minerals are summarized.

A good index brings the book to a close.

VIII.—Mineralogy. By A. H. Phillips. pp. x + 699, with 534 figures in the text. New York: The Macmillan Company, 1912. Price 16*s*. net.

Reasonable in price and size, and well illustrated, the text-book on mineralogy written by Dr. Phillips, the professor of mineralogy at Princeton University, may safely be commended to the use of students who, while not wishing to specialize in crystallography or mineralogy, desire to acquire sufficient working knowledge of these subjects to enable them to determine the minerals, whether megascopic or microscopic, constituting the rocks which they may happen to be investigating. The author has successfully contrived to avoid unnecessary abstruseness without sacrificing lucidity or slurring over difficulties.

The book is divided into three parts, viz. Crystallography, Descriptive Mineralogy, and Determinative Mineralogy, of which the second is about as long as the other two together. The author considers at some length the morphological characters of crystals, and makes use of Miers' nomenclature for the classes of crystalline symmetry. Twinning and parallel growths are amply treated in the chapter on the relation of individual crystals. The measurement of crystals and the use of the goniometer are somewhat perfunctorily dealt with, but the optical properties are fully and clearly discussed. Chapters on the other physical characters, such as cleavage and fracture, specific gravity and its determination, structure, colour, streak, lustre, phosphorescence, and fluorescence, and on the relation of minerals to the elements, and the origin of minerals are included in the next part. The description of the principal mineral species, which takes up the bulk of the second part, is well arranged. Under each species are given its chemical and physical properties, the nature of its occurrence, and its use, and illustrations of typical crystals or specimens are in many cases included. The third part will be found of great practical use. It includes descriptions of the apparatus and reagents required for blowpipe work and simple chemical tests and a series of useful tables. A well-arranged index enhances the value of the book.

IX.—VOLCANOES: THEIR STRUCTURE AND SIGNIFICANCE. By T. G. BONNEY, Sc.D., LL.D., F.R.S., Emeritus Professor of Geology at University College, London. Third edition. 8vo; pp. 379, with 16 plates and 21 text-illustrations. London: John Murray, 1912. Price 6*s.* net.

THIS volume, issued in a fiery red cloth, has evidently met with approval from the "ordinary reader" to whom primarily it is addressed. Success is indicated by the fact that a third edition has been required in the course of fourteen years. The work, indeed, is written in what may be called a fairly popular style, technical terms being avoided as far as possible, and a short glossary of some of those applied to minerals and rocks being appended.

In chapter i the life-history of volcanoes is explained by reference to Vesuvius, Stromboli, Bandai-san in Japan, Krakatoa, the Soufrière of St. Vincent, Mont Pelée in Martinique, Cotopaxi, Kilauea, and Mauna Loa, and the subject is illustrated by some good views, including one of the great 'spine' of Mont Pelée. Submarine eruptions, mud volcanoes, and geysers are described, but we miss a reference to the submarine formation of pillow-lavas.

In chapter ii the structure and classification of igneous rocks receive attention, and illustrations are given of volcanic dust, pumice, lava, bombs, and the columnar jointing of basalt. Then follow, in chapter iii, accounts of the dissection of volcanoes, naturally illustrated in the regions of Auvergne and the Eifel, from which latter district a striking view is given of the crater lake, Weinfelder Maar. The subject leads on to that concerning the ruins of more ancient volcanoes, among them Arthur's Seat at Edinburgh. Here differences of opinion have been expressed, but we may question now whether "the majority of geologists maintain that there were two distinct epochs of outbursts". In the GEOLOGICAL MAGAZINE for 1911 (p. 133) it was noted, in a review of the Geological Survey Memoir on Edinburgh (second edition), that the re-survey of Arthur's Seat led to the confirmation by the Survey of the final views of Maclaren and the conclusions of Professor Judd, that but one period of volcanic activity was represented. A reference to this might have been given, as the author expresses himself in favour of the belief that the outbreaks "were separated by a very considerable interval of time".

Fissure eruptions are dealt with in reference to volcanic mountains where great outbursts take place, and also to those areas, such as the Snake River plain in Idaho, that "are characterized by the general absence of cones", and by the large extent of land covered by lava-flows.

In chapter iv is given a brief account of the geological history of British volcanoes. Here some advances have been made since the publication in 1897 of Sir A. Geikie's great work on the subject, to which the author rightly gives prominence. At Brent Tor lavas of Upper Devonian and Carboniferous age are now recognized by the Geological Survey (*Geology of Tavistock*, etc., 1911, p. 51); Mr. Harker's views on the Sgùrr of Eigg might have been explained a little more fully than in a footnote, and his researches on the Tertiary igneous rocks of Skye should have been mentioned by the author when dealing with the controversy between Professor Judd and Sir A. Geikie. He need not then perhaps have abstained from any expression of opinion on the matter.

Chapter v, on the distribution of volcanoes, is followed by a final chapter on the theories of volcanoes. Here, as in the previous criticisms we have ventured to make, we must bear in mind the author's reminder that his "aim in writing has not been the examination room". At the same time he has left some of his general conclusions as they were written for the first edition in 1898, though admitting that "since then important advances have been made". In treating of the origin of volcanoes he alludes to earth movements as probably "potent agents in causing molten rock to change its position"; he maintains that the expansive form of steam is "a prime factor in the explosive phenomena", and that though much of the water may have been added at a late stage in the history of an eruption, "yet water may also have been present in the magma from the very first, or may have gained access to it at a much earlier stage in its history." While referring to Dr. A. Brun's view that water plays but a small part in the explosive phenomena of volcanic eruptions, reference should have been made also to the important volume on *The Natural History of Igneous Rocks*, by Mr. Harker (1909), who argues that there is sufficient water in the deep-seated molten rocks to explain the aqueous phenomena displayed in volcanic eruptions. Nevertheless, we agree with the author that it is difficult to account for the phenomena "without supposing a marked and local increase of the water originally present in the magma".

X.—Earthquakes.

THE Bulletin of the Seismological Society of America (vol. ii, No. 3, 1912) contains, among other articles, an historical account of the "Great Earthquakes in the Island of Haiti", by Mr. J. Scherer. Particulars relating to "The Hawaiian Earthquakes of 1868" are given by Mr. C. H. Hitchcock, now a resident at Honolulu. The disturbances have occurred in association with eruptions from Mauna Loa and Kilauea, and it is pointed out that there is a sympathetic connexion between the two volcanoes. Although the lava from one issues at an altitude of 12,000 feet and from the other at 3,500 feet, synchronous eruptions have taken place when the pressure of lava was most potent, and they have been accompanied by strenuous earthquakes. In the light of present knowledge, Mr. Hitchcock states that the chief events in the history of the volcanic displays are as follows: (1) illumination over Mauna Loa, (2) earthquakes, (3) discharge from Kilauea, (4) landslide, (5) great sea-waves, (6) eruption and flow of lava from near Mauna Loa to Kilauea. In 1868 the lava gushed out from an elevation of 5,600 feet and along an earthquake fissure a mile in length, that coincided in the lower part of its course with the western edge of the plateau. It is remarked that the earthquakes belong to the class denominated volcanic rather than tectonic, and that from the destructive effects of the latter Hawaii is immune. The quaking is produced by the passage beneath the surface of lava which is endeavouring to escape. Eventually vertical fissures are formed, and the lava wells out. In another paper Mr. A. C. Lawson gives a description with illustrations of "Recent Fault Scarps at Genoa, Nevada".

XI.—Ground-water and Springs.

Grundwasser und Quellen. By Dr.h.c. Hans Höfer von Heimhalt. pp. xi + 135, with 51 figures in the text. Braunschweig: Friedr. Vieweg & Sohn, 1912. Price 4 marks.

THE provision and maintenance of a plentiful supply of good drinking water is a question of primary importance to the inhabitants of every town or city, or any place where men crowd closely together, and a satisfactory answer to it calls for the aid of the chemist to test the purity of the water, and of the engineer to pump and convey it, and, in the first instance, of the geologist to determine the best and most suitable source of the desired supply. We must not forget, too, that springs which are not ordinarily potable may have valuable medicinal uses. The subject is one that lies somewhat outside the scope of ordinary textbooks on geology, and Dr. Höfer von Heimhalt has by this book met a distinct gap in scientific literature; the treatment, while adequate, is simple in style, and the avoidance of unnecessary technicality renders the book suitable to a wide circle of readers.

The book opens with a short section on the hardness of water and the factors which govern the suitability of water for drinking purposes. The next deals with the more or less devious paths by which the moisture present in the atmosphere ultimately finds its way by condensation and infiltration underground in the shape of water, and the author points out how large a part mountains play in feeding the underground supply by causing an ample precipitation of moisture. In the third section he discusses at some length the various types into which underground water may be classified according to the formation of the strata carrying it, and the change produced in the water-level by steady pumping. Incidentally the danger of removing water from an unstable sand layer is emphasized; a danger, moreover, that has to be reckoned with even when the object of the boring is not water, but one of the shallow or deep tunnels with which we are so familiar in London. The excellent diagrams with which the text is liberally illustrated show clearly that, although haphazard well-sinking may often be successful in finding water, yet to get the best results proper study of the stratigraphical geology of the district is essential. Mineral and hot springs and the causes of the mineralization and the elevation of temperature are considered at the close of the book. Altogether the work is one that we may confidently recommend to all interested in hydro-geology. The absence of an index, however, is to be deplored.

XII.—Glasgow Geological Society.

THE Transactions of this Society for 1911–12 (vol. xiv, pt. iii, 1913) contain a paper by Professor J. W. Gregory on "The Polmont Kame and on the Classification of Scottish Kames". The Polmont kame extends for a length of about 4½ miles, from Callendar Park, near Falkirk, to the south of Bo'ness High Junction Station. It is composed of water-worn gravel, has a general width of 10 to 40 yards at the base, rises from the adjacent ground from 10 to 50 feet, and slopes at angles of from 15° to 25°. It rests on the main Boulder-clay of the district, and was probably formed at the same time as the Boulder-clay of the drumlins to the north. The author regards the Polmont ridge as a marginal deposit, formed by the wash of water down an ice-slope, and not fluvio-glacial as in the case of eskers and certain of the Scottish kames; and he describes the Polmont kame as 'glacieluvial', a term suggested by Professor Phillimore.

Mr. G. W. Tyrrell gives an account of "The Petrology of the Kilpatrick Hills, Dumbartonshire; with notes on the Scottish Carboniferous Basalts". He also describes some "Variolites from Upper Loch Fyne and Skye". Mr. W. R. Smellie deals with "The Sandstones of the Upper Red Barren Measures to the east of Glasgow", strata which overlie the Productive Coal-measures; he describes the mineral constituents of the rocks and the conditions under which they were deposited, and gives a good view of spherulitic jointing in sandstone.

Among other papers is one "On the Distribution of *Posidonomya corrugata*, Ether., jun., in the Carboniferous Limestone of the Glasgow District", by Mr. Peter Macnair and Mr. H. R. J. Conacher.

XIII.—Brief Notices.

1. The Journal of the Washington Academy of Sciences, January 19, 1913, gives the result of Dr. H. E. Merwin's investigations in searching for liquids of high refraction which would be suitable for the determination of minute grains under the microscope by the Becke or similar method. Mixtures of methylene iodide with tin and arsenic iodides and sulphur give liquids ranging from 1·764 to 1·868, and by dissolving arsenic sulphide in methylene iodide 2·28 may be reached. He also describes reliable melts which may be used in the same way: arsenic and antimony iodides dissolved in piperine, 1·68 – 2·10; sulphur with arsenic sulphide, 2·1 – 2·6; piperine with rosin, 1·546–1·682; rosin with camphor, 1·510–1·546.

In the same Journal, January 4, 1913, Dr. F. E. Wright describes a simple accessory to the vertical illuminator used in the microscope, which enables the observer to produce apertures of any desired size in any part of the field, and at the same time to eliminate disturbing rays.

2. In the American Journal of Science, 1913, vol. xxxv, pp. 63–82, Dr. F. E. Wright discusses the methods available for producing oblique illumination in the petrological microscope, and recommends the use of either a sliding stop in the lower focal plane of the condenser, or placing the index finger below the condenser and observing the edge of the shadow cast by it. He proceeds to consider the utility of the method in the determination of relative refractive indices, and points out that the interference phenomena between crossed nicols in oblique illumination and in convergent light are precisely similar. Incidentally he draws attention to a useful field method of distinguishing between calcite and dolomite. The powdered mineral is placed in a drop of monobromonaphthalene between two glass slips and studied with a lens in oblique illumination. In the case of calcite the grains have coloured fringes.

3. In the Proceedings of the United States National Museum, vol. xliv, Mr. G. P. Merrill describes the meteoric stone found in 1911 near Cullison, Pratt County, Kansas, and said to have fallen there on December 22, 1902. The mass, which weighs 10·10 kilograms, is now in the United States National Museum. It is so dense and fine-grained that it resembles a weathered boulder of a trappean rock, but an examination of a thin section at once revealed its true character. The meteorite has an interesting chondritic structure, and shows signs of brecciation. It probably formed part of a much larger mass.

4. Chilean Borate Deposits.—Mr. R. T. Chamberlin discusses "The Physical Setting of the Chilean Borate Deposits" (*Journ. Geol.*, Chicago, xx, p. 763, Nov.–Dec., 1912). He points out that throughout the extent of the great plateau, which rises from 12,000 to 13,000 feet above sea-level in Chile, Bolivia, and Peru, there are numerous lakes, saline marshes, and beds of former lakes, mostly with no outward drainage. The large lakes of Titicaca and Pampa Aullagas are well known, but there are many minor lake-flats, dry or nearly so, which escape notice. It is on some of these old lake-bottoms that the great borate deposits of South America occur; but it is significant that the lacustrine tracts which contain borax, mostly lie close to the volcanoes of the Western Cordillera. Away from the volcanoes, whether eastward over the central plateau, or westward down the long desert-slopes leading towards the coast where the nitrate beds abound, the borates rapidly disappear. They thus seem to be related to the volcanoes. The nitrates occur on open salinas at less elevations, 3,000 to 5,000 feet. The borax fields are located high up on the edge of the tableland close to the base of the big volcanoes. Both nitrates and borates are dependent for their accumulation and preservation upon the extreme aridity of the region.

5. Rothamsted Experimental Station, Harpenden. — In his Annual Report for 1912, the Director, Dr. E. J. Russell, remarks in connexion with researches on soils: "Our new conception is that the soil organisms may be divided roughly into two groups in their relation to the processes of food production: a useful group and a detrimental group. The latter are, speaking generally, more readily killed than the former. Conditions that are harmful to active life in the soil tend therefore to reduce their numbers, and lead to an increased activity of the useful bacteria. On the other hand, conditions favourable to active life tend to keep up the detrimental organisms, and therefore to reduce the useful bacterial activity. We have thus been able to render intelligible a number of obscure and paradoxical effects that have hitherto caused considerable perplexity. It has already been observed by practical men in various countries that certain soil conditions harmful to the growth of organisms were ultimately beneficial to productiveness: such are long continued and severe frost, long drought (especially if associated with hot weather), sufficient heat, treatment with appropriate dressings of lime, gas lime, carbon disulphide, etc. Further, it has been observed that conditions which are undoubtedly favourable to life, such as the combination of warmth, moisture, and organic manures found in glass houses, lead to reduced productiveness after a time."

REPORTS AND PROCEEDINGS.

Geological Society of London.

(i) *April* 9, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Variation of *Planorbis multiformis*, Bronn." By George Hickling, D.Sc., F.G.S., Lecturer in Palæontology and Demonstrator in Geology in the Victoria University of Manchester.

The writer gives an account of an investigation of the above-named Miocene Gasteropod, based on a suite of 532 specimens from a single block of stone. The shells of this type from the Steinheim deposits were formerly investigated by Steinmann, Hilgendorf, Hyatt, and others. Many species and sub-species were founded by those writers, who also constructed genetic series which were described as following a stratigraphical sequence. The specimens considered in the present paper include several of the species and sub-species of Hyatt. Since, however, these individuals were clearly all living together, and all the types appeared to pass one into the other by insensible gradations, it seemed doubtful whether they could properly be regarded as constituting more than a single species. Accordingly a study was made of the variation in height presented by the shells, which include every gradation between perfectly discoid forms and types with a spire the height of which considerably exceeds the diameter of the base. By sorting the whole of the shells into ten grades, according to height, it was shown that forms of mean height were common, while extreme forms were rare, the height being distributed, in fact, according to a typical 'variation curve'. If more than one species were really present, it is in the highest degree improbable that the various types should be distributed in the proportions actually found, and this is taken as the most satisfactory proof possible of the specific unity of the group.

It is shown that the shells also vary extensively in respect of the amount of carination, the degree of involution, the form of cross-section of the whorls, the form of aperture, and the stage of development at which various characters are acquired, the variation in each character being, however, 'continuous.' The ontogeny of the various characters is considered, and the species is shown to be highly variable at an early stage, the mature characters being largely independent of early variations.

A discussion is given of the bearing of the inquiry on the stratigraphical application of palæontological data.

2. "The Structure and Relationships of the *Carbonicolæ*." By Miss M. Colley March, M.Sc. (Communicated by Dr. G. Hickling, F.G.S.).

The evidence for the relationship of the *Carbonicolæ* to the Unionidæ, based on shell-structure, muscle-scars, form, habitat, ligament, and hinge-teeth appears insufficient. The first five of these characteristics are shared with obviously unrelated groups. With regard to the last—the teeth—as seen in developed specimens and reconstructions from sections, they seem to be absent. The hinge-apparatus appears to consist of a cardinal plateau, grooved for the reception of an internal ligament. The hinge-plate and ligamental groove are absent in *Carbonicola antiqua*, very poorly represented in *C. turgida* and similar forms, and most highly developed in *C. aquilina*. Another fact which argues against the relationship of the Unionidæ to the *Carbonicolæ* is the absence of ornament in the latter group and its presence in the former. This holds good whether the ornament is considered to be due to the effect of the glochidial hooks in the young shells, or to be the remains of ornament; because in the former case it implies the absence of the glochidial stage, and in the latter it implies descent from an unornamented ancestry.

The position of the *Carbonicolæ* appears to be unsettled, and to be possibly quite different from that of any of the Pelecypoda yet studied; because, according to Bernard's work, the cardinal plateau is developed subsequently to the hinge-teeth, while in the *Carbonicolæ* it is acquired independently of them, specialization taking place in the ligament, for the reception of which the plateau is developed and specialized.

(ii) *April* 23, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

Professor E. Hull described the large chart of the North Atlantic Ocean which was hung on the wall. This chart had been prepared to illustrate the paper which he had read at the meeting of the International Zoological Congress held at Monaco in March, to show the mode of migration of animals by land-connexion between Europe and the American Continent, due to the great uplift of the whole region by several thousands of feet during the Mio-Pleistocene Epoch. The chart showed at a glance the submerged structure of the ocean-bed and bordering coasts on both sides of the ocean, indicating a rise of 1,000 to 1,200 fathoms (6,000 to 7,000 feet) during the culminating stage of the Glacial Period. This was proved by the fact that the channels of the existing rivers—such as the Loire, the Adour, the Mondego, the Tagus, and the Congo—were continued down to the depths above named, across 'the Continental Platform' and 'the Great Declivity' to the floor of the Abyssal Ocean. The details had been worked out by means of the soundings taken from the Admiralty charts and the isobathic contours, the details of which are recorded, with the charts appertaining thereto, in the speaker's *Monograph of the Sub-Oceanic Physiography of the North Atlantic Ocean.* In the view of the speaker this great uplift of the Northern Hemisphere was the *vera causa* of the Glacial Period or 'The Great Ice Age' of Professor James Geikie.

The following communications were read:—

1. "On the Fossil Flora of the Pembrokeshire Portion of the South Wales Coal-field." By Reginald H. Goode, B.A. (Communicated by Dr. E. A. Newell Arber, M.A., F.G.S.)

Of the fifty-three determinable species of fossil plants obtained from the Pembrokeshire portion of the South Wales Coal-field, three are new species. One may be referred to *Linopteris brongniarti*, Gutb., a plant which has not with certainty been found before in Britain.

From the palæobotanical evidence it is clear that the so-called 'Pennant Grit' of Pembrokeshire cannot be regarded as the equivalent of the Pennant Grit of the main portion of the South Wales Coal-field, for the plants indicate that these beds are Middle Coal-measures, and do not belong to the Transition Series. The Lower Coal Series also clearly belongs to the Middle Coal-measures; and the Settlings Beds, and perhaps the Falling Cliff Beds as well, lie probably at a higher horizon than the Lower Coal Series as developed farther east along the Saundersfoot coast, and even possibly higher than the Timber Vein group.

Until more plants have been obtained from the so-called 'Millstone Grit' of Pembrokeshire, it is impossible to fix definitely the horizon of these beds from the palæobotanical evidence. However, from the fossil plants obtained in the so-called 'Millstone Grit' of Monkstone Point, and in neighbouring beds belonging to the Lower Coal Series, between which there is no apparent unconformity, it is evident that these particular beds, assigned to the Millstone Grit, probably belong to the Middle Coal-measures.

When the fossil plants which have been obtained from the Pembrokeshire Coal-field are compared with those which have been recorded from the main South Wales Coal-field, it is evident that there are considerable differences in the occurrence of the species.

Thirty-two fossil plants have been obtained from the Middle Coal-measures of Pembrokeshire which have not as yet been recorded from those of the main South Wales Coal-field, and hence are additions to our knowledge of the flora of the Middle Coal-measures of South Wales.

2. "The Halesowen Sandstone Series of the Southern End of the South Staffordshire Coal-field; and the Petrified Logs of Wood found therein at Witley Colliery, Halesowen (Worcestershire)." By Henry Kay, F.G.S. With an Appendix on the Structure of a New Species of *Dadoxylon*, by E. A. Newell Arber, M.A., Sc.D., F.L.S., F.G.S.

The Halesowen Sandstones are separable from the Old Hill Marls by a series of passage-beds consisting of conglomerate bands, marl bands, and ironshot sandstones.

At the summit of the series is Professor Charles Lapworth's "*Spirorbis* Limestone Group", which is renamed the "Illey Group" in consequence of the discovery of *Spirorbis* limestone at other horizons.

The Halesowen coal-seam and associated beds of blue clay form a definite intermediate horizon traceable across the coal-field. On this is based a classification consisting of—

	Thickness in feet.
(5) The Illey Group	100–120
(4) The Hasbury Group	120–150
(3) The Halesowen Coal and Clays	10–50
(2) The Witley Group	200
(1) The Passage Beds	0–100

The area is folded into two anticlines with a deep central syncline ranging south-south-eastwards, and the strata have a persistent south-south-easterly dip. The northern face is let down by a fault repeating the lower beds. Other faults throw southwards, and yet others intersect the anticlines. Unconformities occur at the base and at the summit of the Hasbury Group in the Wassel Grove area, the former being largely buried by horizontal members of the group. Mining operations show the existence of a buried anticline with the full Coal-measure Series, but cutting out successively the Old Hill Marls, the Passage Beds, and a great part of the Witley Group. This is cut off by a fault only from the exposed Netherton Anticline immediately on the north, the uprise of which in early Upper Carboniferous time is therefore inferred.

The Keele Beds rest unconformably near the buried anticline upon the Illey Group, and upon various members of the Hasbury Group, and are themselves much reduced in thickness. Additional uplift of the anticline in later Upper Carboniferous time is suggested as the cause.

The Witley Colliery railway-cutting shows big logs of petrified wood very finely preserved by calcite, and indisputably of Upper Carboniferous age. The wood has been examined by Dr. Newell Arber, who finds it to have Araucarian affinities, but of a species new to science. In consequence of its Palæozoic age, it is referred to the genus *Dadoxylon*. The type of preservation is also new to this horizon in this country, and the discovery of *Dadoxylon* at Witley constitutes a new record for British Upper Carboniferous rocks. Among the associated plants are *Calamites*, *Lepidodendron*, etc.

(iii) *May* 7, 1913.—Dr. Aubrey Strahan, F.R.S., President, and afterwards W. Whitaker, B.A., F.R.S., F.G.S., in the Chair.

The following communications were read :—

1. "The Bathonian Rocks of the Oxford District." By M. Odling, M.A., B.Sc., F.G.S.

In this paper the author describes the lithology, palæontology, and stratigraphy of the Bathonian rocks north of Oxford, from the evidence afforded by numerous quarries and well-borings and by the Ardley Cutting on the Great Western Railway (new Birmingham main line).

The general sequence is as follows :—

		Thickness in feet.
CORNBRASH.	Rubbly non-oolitic limestone, with occasional marl bands	8–17
	Slight unconformity.	
FOREST MARBLE.	Coarse shelly and oolitic limestones largely false-bedded. When traced eastwards the limestones are largely replaced by marls; and finally the series is represented by green and blue clays with minor bands of limestone	21
	Well-marked unconformity.	
GREAT OOLITE.		
Block 1.	Compact, fine-grained, pure limestones, with a local blue or green clay about the centre. The variation in thickness is largely due to erosion	7–13
	Well-marked eroded surface.	
Block 2.	Compact limestones of a coarser texture than those of Block 1. The full thickness is exposed only in the Ardley Cutting, where it is 15 feet. The thickness to the base of the '*Nerinæa* Rock' is about 6 feet at Ardley and 17 feet in the Gibraltar Quarry, 3 miles away to the south-west	—
Block 3.	Clays and sandy argillaceous limestones, now exposed only in the Ardley Cutting	7½
FULLONIAN.		
Upper Beds.	Compact rock and clay, very fossiliferous	5
	Fullers' Earth Rock	4
	'*Concinna* beds'	4½
	(Position of the Stonesfield Slates.)	
Lower Beds.	'Neæran Beds,' consisting of a series of semi-estuarine green clays, with one band of limestone about the centre . . about	16
	Chipping Norton Limestone, consisting of sandy and argillaceous limestones	12

After a general description of the series, the principal points of interest in the different sections and their mutual relations are described; and the author points out that, although no definite zones can be formulated, the different horizons are readily recognizable by their assemblage of fossils.

The chemical and microscopic structure of the rocks is dealt with, and the conditions of deposition and stratigraphical relationship of the different members of the series are discussed. In addition, some peculiar structures from the Chipping Norton Limestone are described, and the author adduces his reasons for considering them to be annelid tubes.

A complete list of the fossils is appended, showing the horizons and exposures from which they have been obtained; tables giving the correlation between different exposures are also added.

2. "On the Petrology of the Kalgoorlie Goldfield (Western Australia)." By James Allen Thomson, M.A., D.Sc., F.G.S.

The district described comprises an area about four miles long by one mile in breadth. Towards its southern end the auriferous lodes are very rich (The Golden Mile), but in the northern end they are not so productive. The information as to the geological structure has mostly been obtained from mining plans, shafts, and workings. The rocks have a general north-north-westerly strike, and most of the junctions are faulted. In "The Golden Mile" the central feature is a boss or broad dyke of quartz-dolerite, which forms a prominent ridge flanked by amphibolites and greenstones. The quartz-dolerite is cut by dykes of albite-porphyry, and west of the main ridge similar porphyries are frequent. Gold is found principally in shear-zones, impregnated with sulphides and tellurides, and is most abundant in the lodes of the quartz-dolerite.

The rocks for purposes of description are divided into—

(A) Sedimentary.—Of these the most distinctive are conglomerates and grits, the former containing pebbles of quartzite and of albite-porphyry.

(B) Igneous.—These are often very highly altered by metamorphism (inducing schistosity and partial recrystallization) and by metasomatic action. They include—

(1) Fine-grained amphibolites; altered basic igneous rocks—probably lavas and tufts.

(2) Fine-grained greenstones; slightly schistose aggregates, probably related to the fine-grained amphibolites in origin.

(3) 'Calc-schists': whitish-green rocks, which are closely connected with the greenstones and merge into them.

(4) Peridotites, serpentines, etc., often filled with carbonates, but perhaps comprising originally enstatite-peridotites as well as other types. These rocks form the eastern part of the northern end, and include talc-magnesite rocks and fuchsite-magnesite rocks.

(5) Hornblende-rocks or pyroxene-amphibolites, probably occurring as dykes in the peridotites.

(6) Lustre-mottled amphibolites, containing remains of felspar, and originally hornblende-dolerites.

(7) Epidiorites, uralitized and saussuritized gabbros or ophitic dolerites, not very numerous.

(8) Quartz-dolerites and their derivatives — amphibolites usually coarse-grained, with a considerable amount of interstitial micropegmatite. This is the important rock of 'The Golden Mile'. It contains very coarse pegmatitic veins, and is often to a great extent albitized. It presents a great variety of types due to different stages and kinds of alteration, and many of these phases are difficult to recognize as derived from the quartz-dolerites.

(9) Albite-porphyrites (with hornblende and biotite) and albite-porphyries. Secondary minerals are common in the rocks of this group.

(10) Jaspers and graphitic schists. These traverse all the other rocks, occurring as lodes or bands, and may closely resemble sedimentary schists. They sometimes are found running on each side of dykes of albite-porphyry. Their mode of origin is not quite certain, but they are intimately connected with the igneous rocks.

The relation and the sequence of the rocks of Kalgoorlie are next discussed.

The greenstones, fine amphibolites, and calc-schists are regarded as the old 'country rocks', into which the others are intrusive. They are probably a complex of basic lavas, ashes, etc., greatly altered.

The quartz-dolerites, hornblende-dolerites, and pyroxenites are very closely related one to the other, and show every grade of transition. Probably the peridotite group is merely the early basic facies of the quartz-dolerite series, and the porphyries and porphyrites, which were the last rocks intruded, are regarded as being derived from the same magma.

The metasomatic changes and origin of the ores are then considered. The great characteristic of this gold-field is the prevalence of albitization in the auriferous districts. From this, and from a general consideration of the rock-facies developed from the magma, it seems probable that we have in Kalgoorlie an instance of the production of auriferous lodes by rocks belonging to the same class as the pillow-lavas and their diabases and soda-granite-porphyries (the spilitic suite of igneous rocks).

The paper contains a large number of chemical analyses, principally carried out by the chemists of the Geological Survey of Western Australia. By the kindness of the Director of that Survey the author has also been able to make use of the specimens in the Survey cabinets, in addition to those collected during his own examination of the gold-field.

CORRESPONDENCE.

GRANITE AND CRITICAL TEMPERATURES.

Sir,—I have to thank Dr. Johnston-Lavis for two reprints, and especially for a marked list of 161 of his papers.

As my critical-temperatures inquiry has been confined to low-temperature plutonic rocks, down to their associated quartz-veins in adjacent sedimentary rocks, I cannot discover how I have in any way invaded Dr. Johnston-Lavis' field of work, either for agreement or dissent. There is no issue between us. His temperatures are far above the critical temperature of water, mine are almost entirely below it.

With respect to the possibility of granite cavities and fissures at great depths, which Dr. Johnston-Lavis denies, Sir T. H. Holland, in the Magazine for last month, cites Professor F. D. Adams as having proved that empty cavities can exist in granite under pressures equivalent to a depth of at least 11 miles, and at still greater depths if filled with liquids (Geol. Mag., 1913, p. 170).

Once-fissured granite is quite common, re-compacted by invasion of later granitic material. This is the fact, whether theoretically possible or not.

A. R. HUNT.

SOUTHWOOD, TORQUAY.
May 5, 1913.

THE RAISED BEACHES OF TORBAY.

SIR,—Mr. Jukes-Browne's somewhat splenetic, chiefly personal, and wholly unexpected attack reminds me of the notice in the American saloon: "Do not shoot the performer. He is doing his best." As a raised-beach performer I enjoy, or once enjoyed, the very small distinction of having presented to geologists the longest list of shells recorded from any single British raised beach. I have therefore been much interested in the subject, and have endeavoured to keep myself abreast of recent discoveries.

Mr. Jukes-Browne, so far as I know, has never done a day's work on beach or raised beach. His attack is easily disposed of. To save space I will employ parallel columns.

A. J. J.-B., 1913.

"Apparently he [Mr. Hunt] has not realized that the whole question of the age of the raised beaches of Devon and Cornwall has entered an entirely new phase since the discovery that the raised beach of Gower (in South Wales) is older than the local glacial deposits." — GEOL. MAG., 1913, p. 236.

A. R. H., 1903.

"Mr. Tiddeman's evidence of the glacial age of the Raised Beaches of the Gower Peninsula has reopened the whole question of the Raised Beaches of the south-west of England."—TRANS. DEV. ASSOC., 1903, p. 318.

I was present when Mr. Tiddeman read his paper on September 11, 1900.

A. J. J.-B., 1913.

"The beaches testify to a subsidence which culminated either just before or during the epoch of maximum glaciation."—TRANS. DEV. ASSOC., 1913, p. 726.

Professor E. HULL, 1913.

"The chart . . . indicating [for Europe and the North Atlantic] a rise of 1,000 to 1,200 fathoms (6,000 to 7,000 feet) during the culminating stage of the Glacial Period."—PROC. GEOL. SOC., 1913, p. 88.

A. J. J.-B., 1913.

"I have discovered what Mr. Hunt meant by . . . a Neolithic flint '*at Hope's Nose*'."—GEOL. MAG., 1913, p. 238.

A. R. H., 1904.

"The mere fact of the discovery of Neolithic *flakes* newer than the adjacent beach at Hope's Nose, Torbay, may be worth a bare record."—GEOL. MAG., July, 1904.

There was nothing concealed, so nothing to be discovered.

"He [Mr. Hunt] indicates three lines of evidence, viz. those of flint implements, Molluscan fauna, and geographical position."—GEOL. MAG., 1913, p. 237.

"Geology, geography, conchology, physics, palæontology, archæology, anthropology, and even micro-petrology [I forgot spelæology, zoology, and chemistry], all seem to incline towards the conclusion," etc.—GEOL. MAG., 1913, p. 107.

I never referred to 'implements'; and there are ten lines of evidence, not three.

When, some time ago, I consulted two imaginary charts, by Mr. Jukes-Browne, of Pleistocene times,[1] I found that in neither did the sea approach the Torbay raised beaches! A sea-beach without a sea is impossible.

Mr. Lamplugh, in the current number of the GEOLOGICAL MAGAZINE, seems to have exactly defined the present position of this raised beach question. He observes that "the correlation has still an element of uncertainty".[2] That is all I at present maintain, viz., that the age of these Torbay beaches has *not* been "fairly well settled".

If Mr. Jukes-Browne can justify his charge, by reference to any passage of mine in the GEOLOGICAL MAGAZINE (since 1890), that I am a "needless fault-finder", I will give £5 to any hospital or to any scientific object that you, Sir, may kindly indicate.

A. R. HUNT.

SOUTHWOOD, TORQUAY.
May 3, 1913.

THE 'CRETACEO-TERTIARY' OF NEW ZEALAND.

SIR,—I noticed that in the November number of the GEOLOGICAL MAGAZINE there was a further criticism of my work on the younger rock system of New Zealand. At this distance it is, I think, inadvisable to detail at great length the exact features of local stratigraphy. This I intend to do in the pages of the Transactions of the New Zealand Institute, the publication in which my first article on this subject appeared. I hope, however, that you will find space for a reply on a few of the more general aspects of the question.

1. Insistence is laid on the fact that below the Oamaru Limestone Cainozoic fossils only have been found, while beneath the Amuri Limestone Cretaceous fossils occur. As a matter of fact, in all those districts where the Amuri Limestone has been found there is a thickness of 500 to 2,000 feet of strata that have up to the present time yielded no fossils, while the Amuri Limestone itself is almost destitute of fossils, though those that have been found are of Tertiary aspect.

The explanation that I have put forward, viz. continuous rapid depression until after the deposition of the limestone, makes it evident that in off-shore and in relatively low-lying localities the deposition of limestone would commence far earlier than in localities that were submerged only slightly before the climax of depression. The thick deposits of foraminiferous ooze which is the nature of the Amuri Limestone must, therefore, represent not merely in its upper part the same horizon as the Oamaru Limestone, but in its lower part a considerable thickness of subjacent beds, be they conglomerates, greensands, or mudstones. One may add, too, that the latest critical statement (1892) of Tate classes the Echinoderms of the Oamaru Limestone (twenty-six species, all extinct) as Eocene with a Cretaceous complexion.

[1] *The Building of the British Isles*, 1888, pp. 294, 300.
[2] GEOL. MAG., 1913, p. 239.

2. The sections 500 miles away in the north of Auckland are again quoted as explanatory of the supposedly misleading nature of the well-known clear section at the Waipara. I have just returned from a visit to these localities, and find that the sections represent inferences only, for in the one case (Kaipara) the section is obliterated by completely slipped ground for a distance of six chains, and in the other (Orewa) for ten chains. In both cases the stratigraphical break in the diagram is placed where the slipped ground is situated. At the Kaipara the original description distinguishes the strata as Jurassic and Upper Tertiary respectively. At Orewa the strata on the two sides of the slipped ground are not fossiliferous, and in the original description neither of them was assigned to any particular geological age.

3. Hutton's stratigraphical break between the two limestones is in Professor Park's article adopted as the plane that separates the Cretaceous from the Tertiary rocks. In 1904 the same author, in a critical description of this district traversing Hutton's work, states in his conclusion (ii) "That the Weka Pass Stone is conformable to the Amuri Limestone". And in his résumé (*m*) "The Weka Pass Stone is always conformable to the Amuri Limestone". He now states that previous to 1912 he had not critically examined the surface of the Amuri Limestone. Surely it is remarkable to make the statements quoted above entirely contradictory of Hutton's work without critically examining the surface upon the nature of which Hutton relied, though it must have been seen. One of his sections in the paper referred to actually represents his view of Hutton's typical exposure. An author who works thus can hardly be taken seriously.

4. May I add a word of personal explanation. Twenty years ago I graduated from the instruction of my revered teacher, the late Captain Hutton, F.R.S. Impressed by his wide erudition and by his capacity for work, I naturally accepted without question his views on New Zealand stratigraphy. To these I clung for many years, and tried to apply them to those districts where I was at work. Difficulties, however, multiplied and in time became insuperable. I finally went to Hutton's typical localities in the confident expectation that information gained there would solve my difficulties. Surprise and regret were great when I found that, in my opinion, the stratigraphical facts had been represented erroneously by my old teacher. The so-called Cretaceo-Tertiary theory never had any attraction for me. Hard facts in field work have compelled me to accept a series of sediments continuously deposited, rising from beds with Cretaceous fossils to others with younger Cainozoic fossils. This was in opposition to my fondest expectations.

P. Marshall,
Professor of Geology, Otago University, N.Z.

University of Otago,
Dunedin, N.Z.
April 4, 1913.

A CORRECTION IN THE PRESIDENT'S ADDRESS.

Sir,—Will you allow me to correct through the medium of your pages an error in a table of borings which forms part of my recent address to the Geological Society. On p. lxxxix the boring at Meux Brewery is said to have passed through 64 feet of Lower Greensand. The beds referred to, though originally described as Lower Greensand, were shown by Professor Judd in 1884 to belong to the Great Oolite Series. There has never been any doubt about the correctness of Professor Judd's determination, and the error is purely one of transcription.

A. Strahan.

Geological Survey and Museum,
Jermyn Street, London, S.W.
May 13, 1913.

SEPTARIAN STRUCTURE.

Sir,—I have read with much interest the article by Dr. Davies in your March issue on "The Origin of Septarian Structure". I should like to say that I have been conducting researches on 'rock structures'—including septarian structure—for over two years. My work is nearly completed, and I hope to publish it shortly. I can only say at this juncture that I have had unique opportunity of observing enormous septarian nodules in situ, and hope to show their relationship to the adjacent rock as pointed out by Dr. Davies. Up to the present, by suitable devices I have been able to make certain rock structures closely allied to septarian structure. An account of these also I hope to submit shortly. I should like to put on record my indebtedness to W. Whitaker, Esq., F.R.S., H. B. Woodward, Esq., F.R.S., Mr. G. W. Butler, Mr. Lionel Walmsley, Professors Garwood, Bonney, and Cole, and others, who have been so kind as to help me with 'raw material' and criticism.

S. Rennie Haselhurst.

9 York Terrace, North Shields.

MISCELLANEOUS.

International Geological Congress, Toronto, August 7 to 14, 1913.—At a meeting of the Geological Society of London, April 9, a letter was read from Professor F. D. Adams, President of the Twelfth International Geological Congress, expressing the hope that Fellows of the Society and British geologists in general would be largely represented at the Congress which is to be held in Canada next August. He added that every endeavour is being used to make the Congress a success, and that excursions have been arranged to almost every accessible part of the Dominion.

Appointments to the Staff of the South African School of Mines and Technology, Johannesburg.—The Council of the South African School of Mines and Technology has made the following appointments to the Staff: Dr. G. S. Corstorphine, consulting geologist, of Johannesburg, to be Principal of the School and Professor of Economic Geology; Mr. J. S. Cellier, mining engineer, of Johannesburg, to be Professor of Mining.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. VII.—JULY, 1913.

ORIGINAL ARTICLES.

I.—TO THE READERS OF THE *GEOLOGICAL MAGAZINE.*

IT may interest our readers if we remind them that with the publication of our July Number the GEOLOGICAL MAGAZINE enters upon the fiftieth year of its existence. The first number was issued in July, 1864, and the first volume consisted of six numbers for the half-year.[1] Consequently the commencement of the fiftieth volume took place in January of the present year. It must be a matter for congratulation to the Editor that during so extended a period he has personally edited every number, excepting three, when he took a long vacation in Italy and could not conveniently deal with proofs. Such a record is probably unique. It is moreover satisfactory to learn that there has at no time been a serious lack of useful material wherewith to fill the pages of the Magazine. In our copy of Vol. I there are lists of Local and Foreign Correspondents; among the former is the name of the Rev. H. H. Winwood, and among the latter are the names of Baron Adolph von Koenen and Dr. Anton Fritsch. Amongst surviving contributors to the 1864 volume may be recorded the Rev. Osmond Fisher, Sir Archibald Geikie, Professor Edward Hull, Sir E. Ray Lankester, and Henry Woodward.

H. B. W.

II.—ON *SOLENOPORA GARWOODI*, SP. NOV., FROM THE LOWER CARBONIFEROUS IN THE NORTH-WEST OF ENGLAND.

By GEORGE J. HINDE, Ph.D., F.R.S., F.G.S.

(PLATE X.)

INTRODUCTORY REMARKS.

SOME years since Professor E. J. Garwood sent to me for examination some pieces of limestone from the Lower Carboniferous rocks in the Shap and Ravenstonedale districts of Westmorland, in which he had observed the rounded outlines of fossils with a structure which appeared to him to resemble that of *Stromatopora*. The rock in which the fossils were embedded was so compact and hard that they could not be extracted, and it was necessary to make sections in various directions in order to ascertain their structure, which proved to be identical with that of *Solenopora*, now well known as one of the

[1] But the *completion* of the *actual* fifty years (or Jubilee of the GEOLOGICAL MAGAZINE) will not be reached until *June, 1914*.—ED.

calcareous Algæ. It is many years ago since this genus was recognized in the Ordovician rocks in North America, Britain, and Russia; more recently it was found in the Silurian rocks of the Isle of Gotland, and in 1894 a species was described from the Jurassic rocks of Gloucestershire and Yorkshire. But until this fortunate discovery of its occurrence in the Lower Carboniferous by Professor Garwood, no example of the genus was known in any of the rocks between the Silurian and the Jurassic.

I am greatly indebted to Professor Garwood for permission to describe this new and interesting species—which I propose to name after him—and for providing me with numerous specimens and sections for the purpose.

Description.

Form and Mode of Growth.

The thallus of this species grows in small, depressed, nodular masses; in their higher stages lobate extensions are produced, which show a tendency to further division. The specimens measured are from 20 to 26 mm. in diameter and about 14 mm. in height. It is uncertain whether they were attached to other bodies or continued free during their growth. They consist of very compact, hard limestone, of a light greyish-brown tint, resembling that of the matrix in which they are enclosed. In a horizontal section of a specimen which has been figured (Pl. X, Fig. 1) concentric lines or bands of a slightly darker tint are seen at regular intervals extending across the thallus, probably indicating periods of growth.

Character and Arrangement of the Cells.

Thin sections taken in a vertical or radial direction through the thallus of this species show the cells with great clearness. Their longitudinal walls are straight and even, but their transverse walls, though sometimes straight, for the most part are slightly concave; the concavity is towards the upper or growing surface of the thallus (Pl. X, Figs. 3, 6). The cells are closely arranged in vertical and transverse rows, and the partition walls, under low magnification, appear to be simple and imperforate. The vertical rows are generally straight and parallel, but through the intercalation of fresh rows of cells by growth they diverge slightly and have a fan-like appearance. The transverse rows form concentric, evenly arched lines, extending across the thallus.

The cells vary considerably in size and form. Some are quadrate, others oblong, and in others the length is much less than the width. The cells in the same transverse row are usually of a corresponding length or height, and it is frequently noticeable that a series of concentric rows of fairly large cells is succeeded by a series of rows of short cells, and this alternation may indicate periods when the conditions were more or less favourable to the growth of the organism.

Seen in cross-section the cells are closely fitted together, and their outlines are very irregular; some are entirely polygonal, whilst the contours of others are partly polygonal and partly rounded (Pl. X, Figs. 4, 5, 7).

Large cells range from 60 to 80 μ[1] in length and from 53 to 66 μ in width; a cell of average size is 50 μ in length by 40 μ in width, whilst a short cell measured 20 μ in length by 47 μ in width.

I have not seen in this species any of the long narrow cells similar to those forming the hypothallus in recent and fossil species of *Lithothamnion*, nor have I met with any indications of conceptacles or other structures which could be regarded as reproductive organs.

The Structure of the Cell-walls.

As a rule but scanty reference is made to the structure of the cell-wall in descriptions of *Solenopora*, owing to the fact that in ordinary thin sections nothing more is shown beyond a partially opaque line or band, without structure, between the cells. But it has been possible to prepare thin sections from some of these Carboniferous specimens of such extreme tenuity that the partition walls are fairly transparent, and exhibit structural details of considerable interest (Pl. X, Figs. 6, 7).

Under the microscope, with somewhat high powers, in the centre of the wall bounding the cells there is shown a very delicate continuous line, which is, actually, a section of an extremely thin, even, imperforate lamina, which forms a median partition in the wall between contiguous cells. It is present in all the walls of the cell whether longitudinal or transverse; in very thin sections it is translucent and in places of a faint pinkish tint. Measured in section this median partition is between one and two microns in thickness, and thus about one-sixth of the average thickness of the whole wall, which varies between 6 and 8 μ.

This median lamina is markedly distinct in character from the main portion of the cell-wall on either side of it, which is composed of very minute granules of calcite, whereas no constituent particles can be recognized in the median plate.

The outer layers of calcite granules on either side of the median plate are less resistant than the lamina itself, and they are frequently broken up and disappear in the preparation of the thin section, thus leaving the lamina as the only representative of the cell-wall. Usually, however, small portions of the granular layers remain, attached to the median plate. The interior area of the cells is now filled with clear calcite.

I am only aware of two references in the literature relating to *Solenopora* to a median structure in the cell-wall of this genus. The first is in the paper by Nicholson & Etheridge on *S. compacta*, Billings, sp., which appeared in the Geological Magazine.[2] On Pl. XIII, Fig. 7, is represented a transverse section of some cells of *S. compacta* (?) from Saak, Esthonia, which are drawn to the same scale as the Figs. 6 and 7 in the Plate accompanying this paper. The Fig. 7 of the Saak specimen, which was drawn by the late Professor Nicholson, shows a definite dark line in the centre of the wall, which may indicate a median lamina of the same character as that in *S. garwoodi*. No reference, however, is made to it in

[1] μ = micron, $\frac{1}{1000}$ of a millimetre.
[2] Geol. Mag., 1885, p. 529, pl. xiii.

the text of the paper. In Fig. 4 of the same plate a dark line is also shown in the longitudinal walls of a Canadian specimen, but it is much thicker and less definite than in Fig. 7. It happens that Fig. 7 was drawn from a section still in my possession, and the dark line shown in this cannot, in my opinion, be interpreted as representing a median partition in the cell-wall, and it is not referred to as such by the authors[1] of the paper.

The second reference is by Professor Rothpletz,[2] who, in describing a specimen of *S. compacta*, states that the walls show a distinct, dark, median line, which also marks the exact boundary between two contiguous cells. It reminded him of the dark line in corals! It is further stated not to be continuous, but perforated at intervals by very fine pores. I strongly suspect that the dark median line mentioned by Rothpletz is of the same character as that in my specimen figured by Professor Nicholson.

The characters of this species from the Lower Carboniferous fully support the conclusion of Dr. A. Brown[3] that *Solenopora* is one of the calcareous Algæ, and this view is also supported by Professor Seward,[4] who places the genus in the Corallinaceæ.

Distribution.

S. garwoodi was first discovered by Professor Garwood in limestone rocks of Lower Carboniferous age, which, in his elaborate memoir on "The Lower Carboniferous Succession in the North-West of England",[5] he has grouped together as a separate subzone, with the present species as the index-fossil, and given it the name of the '*Solenopora*' subzone. The fossils are met with at the Abbey Cliff, Shap District; Stonegill in the Ravenstonedale District; and Low Meathop in the Arnside District; and also at other localities in Westmorland.

EXPLANATION OF PLATE X.

Solenopora garwoodi, Hinde.

Fig. 1. A horizontal section of a nearly complete specimen showing concentric bands of growth. × 2 diams.
,, 2. A radial section of a specimen from Shap Abbey, showing the close arrangement of the cell-rows. × 50.
,, 3. A similar section from Meathop. × 50.
,, 4. A transverse section of a specimen from Meathop, showing the cells. × 50.
,, 5. A transverse section of a specimen from Stonegill. × 50.
,, 6. A radial section of a specimen from Shap Abbey, showing the structure of the cell-walls. × 150.
,, 7. A transverse section of a specimen from the same locality, showing the structure of the cell-walls. × 150.

All the specimens are from the *Solenopora* subzone of the Lower Carboniferous.

[1] Geol. Mag., 1885, p. 533.
[2] Svenska Vetensk. Akad. Handl., Bd. xliii, No. 5 (1908), p. 12, pl. 3, figs. 1–6.
[3] Geol. Mag., 1894, p. 203.
[4] *Fossil Plants*, vol. i, p. 190, 1898.
[5] Quart. Journ. Geol. Soc., vol. lxviii, pp. 449–586, 1912.

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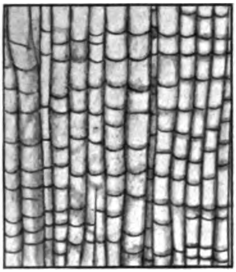

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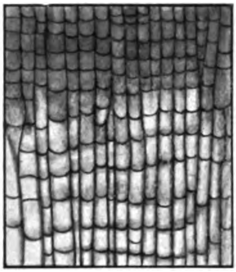

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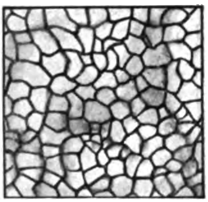

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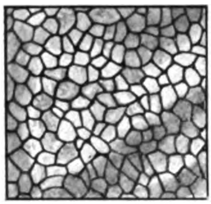

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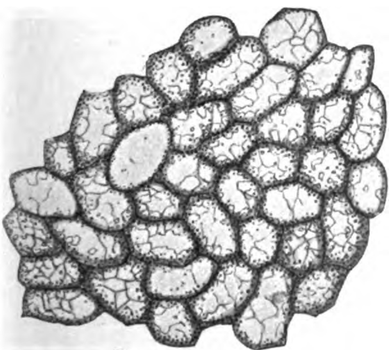

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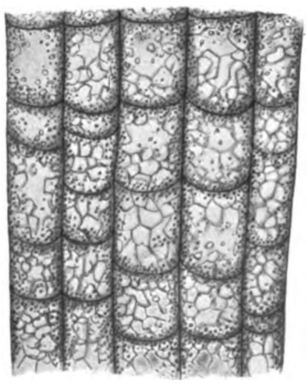

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G. M. Woodward & G. J. Hinde del.

SOLENOPORA GARWOODI, HINDE.

Fig. 1, × 2; Figs. 2–5, × 50; Figs. 6, 7, × 150.

III.—The Position of the Merostomata.

By Henry Woodward, LL.D., F.R.S., F.G.S.

More than fifty years since a great impulse was given to the study of a new and strange group of Palæozoic Arthropoda whose remains were almost simultaneously brought to light in New York, in England, Scotland, and in the Baltic island of Oesel, and attracted the attention of numerous palæontologists both in this country and in America. Among others may be cited Hugh Miller and the elder Agassiz, who at first believed them to be fish (1844), but the latter afterwards was convinced that they were in reality the remains of an enormous Crustacean.

Professor M'Coy gave a weird restoration of *Pterygotus problematicus* in the 5th edition of Lyell's *Manual of Elementary Geology* (1855, p. 420).

Further discoveries of *Pterygotus* made by Mr. Robert Slimon, on the banks and bed of Logan Water, Lanarkshire (1855), were examined by Professor Huxley and Mr. J. W. Salter, and led to the production of a Geological Survey memoir in 1859, illustrated by sixteen folio plates and many text-figures.

Mr. J. W. Salter contributed a restoration of *Pterygotus anglicus* to Murchison's *Siluria* (1859 edition), in which, although happier than M'Coy's figure already referred to, he gives only two pairs of appendages to the head; the thoracic plate, or operculum, is placed *in front* of the mouth, and the lower lip or metastoma is absent.

In the same year a Russian naturalist, Dr. J. Nieszkowski, published an account of *Eurypterus remipes* from the Upper Silurian in the Island of Oesel, Baltic, giving restorations of the upper and under sides of *Eurypterus*, showing the appendages of the mouth in situ and the thoracic plates on the under side of the body immediately behind the mouth.

Following after Salter, Mr. David Page, in his *Advanced Text-Book of Geology* (1859), gives restorations of several forms of *Pterygotus*, *Stylonurus*, *Eurypterus*, etc., all more or less correct, but without descriptions.

Professor James Hall, the veteran geologist of the Albany Museum, was the author of a most valuable monograph (1859–60) giving excellent descriptions and figures of the American species of *Eurypterus* and *Pterygotus* (see his *Palæontology of New York*, vol. iii, pt. i, pp. 382–419*, 80 plates and 10 additional plates), the accuracy of which still remains unchallenged.[1]

In 1862 and 1863 Mr. J. W. Salter contributed descriptions of *Eurypterus* and allied forms of *Pterygotus* (Quart. Journ. Geol. Soc.).

The writer figured and described a very complete example of *Slimonia acuminata* from the Upper Ludlow rocks of Lesmahagow, Lanarkshire, in the *Intellectual Observer*, 1863 (vol. iv, No. iv, pp. 229–37), and of *Eurypterus lanceolatus* (in the Geol. Mag. for 1864, Vol. I, p. 107, Pl. V, Figs. 7–9). In 1865 he figured and described *Stylonurus scoticus*, *Stylonurus Powriei* from the Old Red of Forfarshire, and *Stylonurus Symondsi* from Herefordshire, also

[1] Thirty quarto volumes have been published by the New York State Museum, fourteen of which, on Geology and Palæontology, are by James Hall.

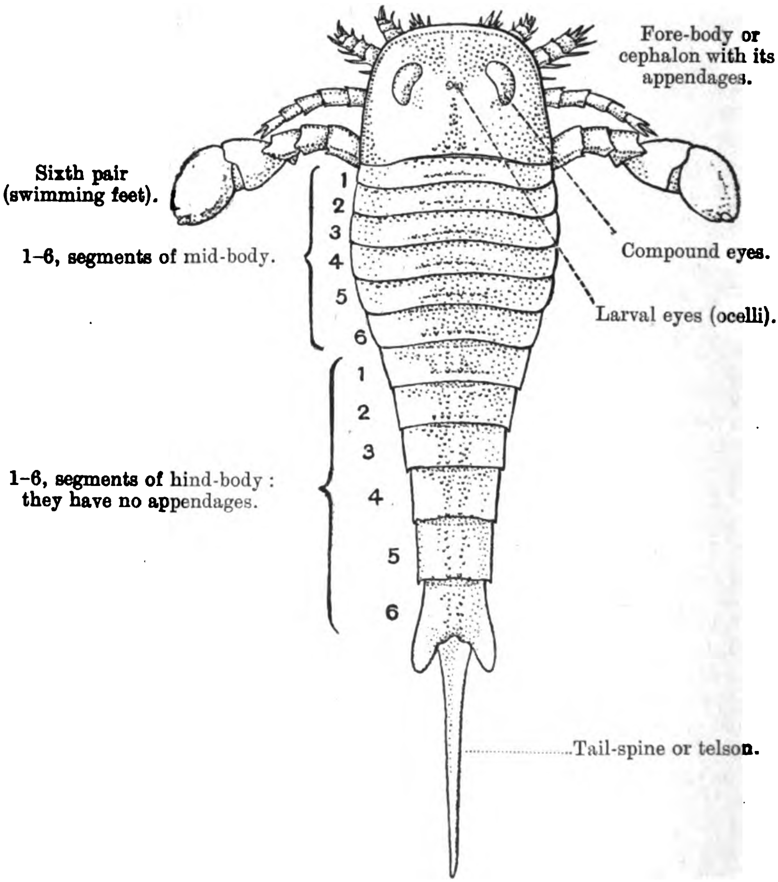


FIG. 1. Upper or dorsal aspect of *Eurypterus Fischeri*, from the Upper Silurian of Oesel in the Baltic. The drawing made from G. Holm's original figure. Nat. size. Reproduced by permission of the Trustees of the British Museum (Natural History).

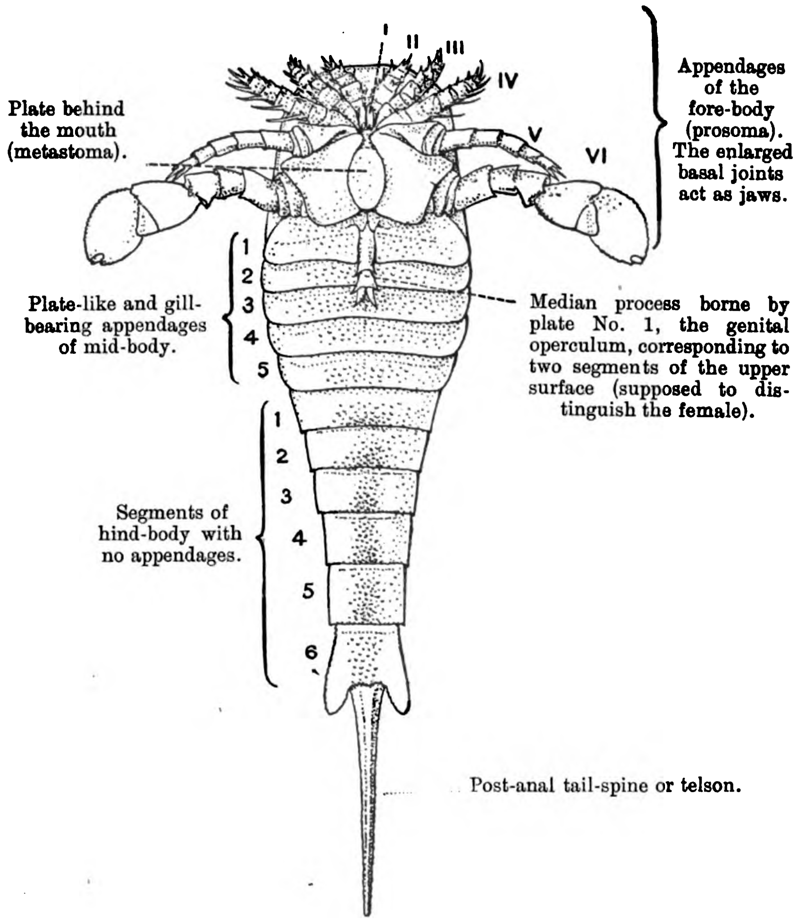


FIG. 2. Lower or ventral aspect of *Eurypterus Fischeri*, from the Upper Silurian of Oesel in the Baltic. The drawing made from G. Holm's original figure. Nat. size. Reproduced by permission of the Trustees of the British Museum (Natural History).

Hemiaspis limuloides from the Lower Ludlow, Shropshire (see Quart. Journ. Geol. Soc., vol. xxi, pp. 482–92, pls. xiii, xiv).

In 1866 I commenced a monograph of the British Fossil Crustacea of the order Merostomata in the annual volumes of the Palæontographical Society, completed in 1878, in which fourteen genera and eighty-three species are recorded and all the then known British species described and figured.

From 1878 to 1911 more than a hundred contributions have been added to our knowledge of this truly wonderful group.

Special reference should be made to the remarkable work of G. Holm[1] on *Eurypterus Fischeri* from the Upper Silurian of Root-si-kul, in the Baltic island of Oesel. Professor J. M. Clarke writes: "Taking for the subject of his investigations the same *Eurypterus fischeri* from Oesel, that had been already studied by Nieszkowski and Schmidt, he succeeded by most clever manipulation in isolating the chitinous test of the animal, which in this locality is not metamorphosed into a carbonaceous film, as in other deposits, and was able to elaborate its organization in such detail that *E. fischeri* has really become the most completely known of all extinct animals, and our exact knowledge of it is quite comparable with that of its recent relatives.

"By comparison with *Limulus*, the differences in the appendages of the first and second sternites were referred to their proper sexes. Many details of structure were discovered, such as the minute cheliceræ, the epicoxite of certain coxal segments, the endostoma of the posterior margin of the mouth, the connection of the metastoma with the gnathobase, the clasping organ of the second endognathite of the male, the originally composite nature of the metastoma, corresponding to the chilaria of *Limulus*, and the interior tubular processes of the female opercular appendage. His work has served to bring out with still greater force the numerous homologies and consequent close relationship of the Eurypterids to *Limulus*."

Figs. 1 and 2 give actual reproductions of this remarkable specimen, showing the dorsal and ventral aspect (pp. 294–5).

To those who are interested in the study of these ancient forms, it may be desirable to mention that a model of *Eurypterus Fischeri* (by Mrs. Blackman) is exhibited in the Zoological Gallery of the Natural History Museum, Cromwell Road, S.W.

Foremost of the long list of modern investigators, and following, as Director of the New York State Museum, in the position so long and honourably held by Professor James Hall at Albany, N.Y., stands the name of Professor John M. Clarke, Ph.D., D.Sc., LL.D., For. Corr. Geol. Soc. Lond., and one of the most able and energetic geologists and palæontologists in North America.

Assisted by Dr. Rudolph Ruedemann, Professor J. M. Clarke issued last year (1912) from the State Museum, Albany, two grand volumes entitled Memoir 14, *The Eurypterida of New York* (one volume of text, pp. 440 quarto, with 121 text-figures, and one volume of 88 plates, several of which are large folding plates, and pp. 441–628,

[1] "Ueber eine neue Bearbeitung des *Eurypterus Fischeri*, Eichw." : Acad. Imp. Sci. Bull. St. Pétersbourg, sér. v, iv, 369, 1896 ; Geol. For. i Stockholm For., Bd. xxi, p. 83, 1899.

of explanations of plates, with a full index at the end). It is delightful to find in these massive tomes such a grand collection of materials relating to the American Merostomata, which the authors have themselves brought together so carefully and studied and described with so much patience and acumen, nor has the contemporary foreign literature on the group been neglected, for every writer will find his work and observations duly recorded and acknowledged.

The volumes just issued by the New York State Museum make us acquainted with no fewer than sixty-six American species, ranging from Professor Walcott's *Beltana Danai*, *Echinognathus Clevelandi*, and *Strabops Thatcheri* of Cambrian age to the *Eurypteri* of the Coal-measures. No *Limuli* are recorded, but they are accepted as next of kin to the Eurypterids on the one hand and to the Scorpions on the other.

Of actual *complete* forms of *American* Eurypterids known and figured by Clarke and Ruedemann in their memoir (vol. ii), may be cited—

Strabops Thatcheri, Beecher. Upper Cambric.
Eurypterus remipes, De Kay. Siluric.
E. lacustris, Harlan. Bertie Waterlime.
E. ranilarva, Clarke. Lockport Limestone.
E. Dekayi, Hall. Waterlime.
E. microphthalmus, Hall. Manlius Limestone.
E. Maria, Clarke. Shawangunk Grit.
E. Kokomoensis, Miller & Gurley. Waterlime.
Eusarcus scorpionis, Grote & Pitt. Waterlime.
E. Newlini, Claypole. Waterlime. (Size, 26 × 13 inches.)
Dolichopterus macrocheirus, Hall. Waterlime.
Stylonurus longicaudatus, Clarke. Waterlime.
S. excelsior, Hall. Catskill Beds. (56 inches long.)
S. cestrotus, Clarke. Shawangunk Grit.
S. myops, Clarke. Shawangunk Grit.
Hughmilleria socialis, Sarle. Pittsford Shale.
H. Shawangunk, Clarke. Shawangunk Grit.
Pterygotus Buffaloensis, Pohlman. Bertie Waterlime.
P. macrophthalmus, Hall. Bertie Waterlime.

To these must be added nearly fifty species described and figured from more or less perfect remains, many of which, however, add greatly to our knowledge of structural details of the group.

The plates are admirably executed and show the minutest features of each species. The eighty-eighth and last plate gives an enlarged figure (× 7) of *Proscorpius Osborni*, Whitfield, Upper Silurian, affording a convenient comparison with *Eurypterus* and other Merostomes.

The following fifty species are arranged in order from the Cambrian to the Coal-measures:—

Beltana Danai, Walcott. Greyson Shales, Montana.
Echinognathus Clevelandi, Walcott. Utica Slate, Oneid Cap.
Eurypterus megalops, Clarke. Frankfort Shale.
E. pristinus, Clarke. ,,
E. stellatus, Clarke. ,,
Eusarcus triangularis, Clarke. ,,
E. (?) *longiceps*, Clarke. ,,
Dolichopterus frankfortiensis, Clarke. ,,
D. latifrons, Clarke. ,,
Hughmilleria magna, Clarke. ,,

Pterygotus nasutus, Clarke. Frankfort Shale.
P. prolificus, Clarke. ,,
Stylonurus (?) *limbatus*, Clarke. ,,
Megalograptus Welchi, Miller. Richmond Group.
Eurypterus prominens, Hall & Clarke. Clinton Beds.
E. sp. Arisaig, Nova Scotia.
Drepanopterus longicaudatus, Clarke. Lockport Limestone.
Eurypterus Boylei, Whiteaves. Elora, Ontario.
E. Pittsfordensis, Sarle. Pittsford Shale.
Stylonurus multispinosus, Clarke. Pittsford Shale.
Hughmilleria socialis, var. *robusta*, Sarle. Pittsford Shale.
Pterygotus Monroensis, Sarle. Pittsford Shale.
Eusarcus cicerops, Clarke. Shawangunk Grit.
Dolichopterus otisius, Clarke. ,,
D. stylonuroides, Clarke. ,,
Stylonurus cestrotus, Clarke. ,,
S. sp. *α*, sp. *β*, sp. *γ*. ,,
S. sp. ,,
Pterygotus globiceps, Clarke. ,,
Eurypterus lacustris, var. *pachychirus*, Hall. Bertie Waterlime.
E. pustulosus, Hall. Bertie Waterlime.
Dolichopterus siluriceps, Clarke. Bertie Waterlime.
D. testudineus, Clarke. ,,
Pterygotus Cobbi, Hall. ,,
P. grandis (Pohlman). ,,
P. Atlanticus, Clarke. Devonic.
P. sp. ,, Gaspé, Quebec.
Eurypterus pulicaris, Salter. ,,
Eurypterella ornata, Matthew. ,, New Brunswick.
Stylonurus (?) *Wrightianus* (Dawson). Portage Sandstone.
S. Beecheri, Hall. Catskill Beds, Penn.
Eurypterus approximatus, Hall & Clarke. Waverly Beds.
E. Masonensis, Meek & Worthen. Coal-measures.
E. Mansfieldi, C. E. Hall. Coal-measures, Penn.
E. Pennsylvanicus, C. E. Hall. ,,
E. potens, C. E. Hall. ,,
E. stylus, J. Hall. ,,

Since the important contributions made to this group by Professor James Hall (1859–62) all zoologists have accepted the correctness of his correlation of *Limulus* with *Eurypterus*, *Pterygotus*, and their allies. But another question was raised by Sir E. Ray Lankester (in 1881)[1] as to whether *Limulus* was indeed a true Crustacean after all, but should be rather considered as an aquatic Arachnide.

If we make a brief comparison of the characters of the three great groups of Limulidæ, Eurypteridæ, and Scorpionidæ, we shall be struck by the family resemblances they offer.

In *Limulus* the body, although compressed, represents by its paired appendages the concealed presence of a common number of coalesced segments. The head-shield bears upon its upper surface both ocelli and compound eyes. On the under side is the mouth with six pairs of chelate appendages, the bases of which serve as mouth organs (save the first pair) and for prehensile or walking-legs at their distal extremities. The mid- and hind-body are coalesced and bear on the under side six broadly expanded and united pairs of plates, the first pair carrying the ovaries and genital pores, the five pairs following

[1] "*Limulus* an Arachnid?": Quart. Journ. Micr. Sci., N.S., xxi, p. 609.

being gill-bearing (branchiæ). The hind-body has no limbs, but to it is articulated a long bayonet-shaped tail-spine (or 'telson').

In *Eurypterus* the head-shield is smaller than in *Limulus* and the body much more elongated and the segments free and movable. The head-shield bears upon its upper surface both ocelli and compound eyes. On the under side is the mouth with six pairs of chelate or simple maxillipeds, the first two pairs serving as tactile organs (chelicerae and antennæ), then three simple spinose limbs, and lastly a pair of larger swimming appendages with well-developed basal jaws and a central oval plate or metastoma. The mid- and hind-body are not coalesced (as in *Limulus*), but the segments are distinct and flexible and adapted to a swimming existence. On the under side, immediately behind the head (as in *Limulus*), is a broadly expanded plate, the operculum carrying on its inner surface the paired ovaries and genital pores, followed by three or more broad plates carrying the gill-packets or branchiæ. The hind-body is destitute of appendages, but to its last segment is articulated a long and slender telson or tail-spine, which in *Pterygotus* is broad and spear-shaped at its extremity.

In *Scorpio* the head is oblong in form and bears on its upper surface ocelli in the centre and groups of eyes at the anterior angles. On the under side is the buccal orifice with short chelicerae in front, and a pair of large chelate pedipalps, followed by four pairs of simple or clawed oral appendages, used in terrestrial locomotion in the living species, and for assistance in swimming in some of the fossil aquatic forms. The mid-body bears a pair of comb-like organs, and also the organs of reproduction (genital openings). The segments following carry three or more pairs of gill-packets or tracheal openings (respiratory organs) adapted for terrestrial existence in the living species, and for aquatic life in the early fossil forms. The six following segments forming the hind-body are narrow and elongated without appendages; to the last segment is articulated the 'telson' or tail-spine, which in modern Scorpions serves as a sting or poison-organ.

We know that *Limulus* has always been aquatic in its habit, and in the earlier forms the segments of the mid- and hind-body apparently were mostly free and movable, and adapted for swimming, as is the case with the young stages in the development of the living king-crab.[1] It is the opinion of Lankester, of Pocock, of Laurie, and others that the early Silurian Scorpions (*Palæophonus*, *Proscorpius*, etc.) were aquatic forms, their remains having been found in truly marine deposits.

The correlation of *Limulus* with such forms as *Eurypterus* and *Pterygotus* naturally suggested a close affinity with the Scorpionidæ, and it is also of interest to note that Scorpions have been met with in America, in Scotland, and in the Baltic area in marine strata associated with *Eurypterus*, *Pterygotus*, and *Limulus*. It is an astonishing fact that two of these types, *Scorpio* and *Limulus*, should have persistently survived through all the accidents and changes of living things, from Silurian times to the present day, and that both

[1] See A. S. Packard, "Development of *Limulus polyphemus*" (Mem. Boston Soc. Nat. Hist., 1870, p. 154); Anton Dohrn, Jenaische Zeitsch., v, p. 6, 1871; A. Agassiz, Amer. Journ. Sci., ser. III, xv, 75, 1878.

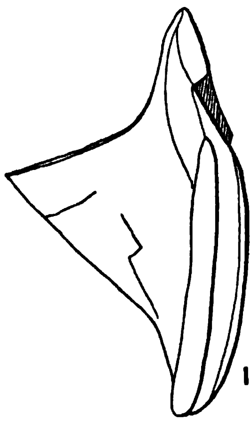
should be found distributed over so vast a geographical area among the living fauna of our globe. They may indeed justly claim to be considered as amongst the oldest living races and the marvels of the animal world.

It is true that the other great group to which they are so closely related, the Eurypterida, has passed away, not having survived beyond the Carboniferous epoch; but as this group certainly appeared earlier on life's scene, it doubtless impressed its mark upon other types of Arthropoda, and quite possibly was the great ancestor of the Scorpions and King-crabs in earlier Cambrian times.

IV.—The Lantern of *Perischodomus.*

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

SOME years ago Mr. D. M. S. Watson and I collected, from the Carboniferous Limestone of Clitheroe, Lancashire, a considerable series of Echinoids. One slab of the limestone (measuring 16 × 12 cm.) is covered by a great number of disjointed plates and other skeletal fragments of a large *Perischodomus*, probably *P. biserialis*, M'Coy. Dr. R. T. Jackson refers to the specimen (*Phylogeny of the Echini*, p. 406), and, as the jaw fragments show features not hitherto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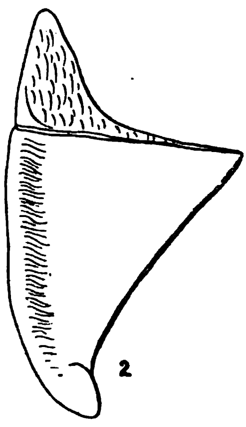
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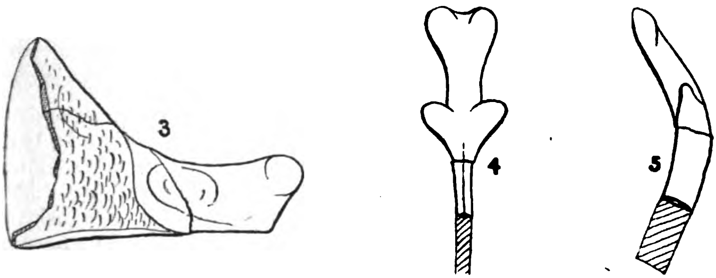
Figs. 1, 2.—*Perischodomus biserialis* (?). Alveolar and interpyramidal views of maxillæ.

described for the genus, it seems advisable to give a brief account of it. The preservation of a compass is a point of special interest, as these delicate structures are known in very few cases in the fossil state.

Maxillæ (Figs. 1, 2).—Fragments of eight of the ten maxillæ are preserved, three of them being very well shown. The two figured examples show the interpyramidal and alveolar surfaces completely. They agree absolutely in measurements, as do all the other fragments as far as can be ascertained. Symphysial margin 16, dental slide 16, total length 24·4, greatest width (margin of epiphysis) 12·3 mm. As is usual among Palæozoic lanterns, the maxillæ are very wide (measured radially) and have the interpyramidal faces considerably curved. The convexity of the outer surface (at the symphysis) is such that the tooth must have projected almost at right angles to the line of the upper part of the pyramid—perhaps working horizontally. None of the specimens show the outer face completely, but the indications point to its being similar in proportions to that of *Archæocidaris nerei* (cf. Jackson, op. cit., pl. x, fig. 6).

Epiphyses (Fig. 3).—Two of these ossicles are shown, one being almost complete and exposed from the side of its articulation with the maxillæ. Its radial width is 12·2 mm., and its height at the outer edge is 10·4 mm. Its inner height is only 4·2 mm. There is a slight concavity on the free part of the surface, and a very low knob at the inner and upper corner. The articulation surface is irregularly and coarsely roughened.

Compass (Figs. 4, 5).—One compass exists on the slab, exposed from the side and upper surface. It is broken, apparently along the



Perischodomus biserialis (?).
FIG. 3. Epiphysis, articular surface.
FIGS. 4, 5. Compass, upper and side views.

suture by which all compasses are traversed, and has been pressed into one of the interambulacral plates. A scar is left on the plate where the compass has been destroyed, and this additional part is indicated on the figures by shading.

The total length, as far as can be ascertained, is 10·5 mm. (measured along the chord). From the outer-muscle prominence to the circular-muscle prominence is 4 mm. From the outer extremity to the fracture (? suture) is 6 mm. The height at the inner (broken) end is 2·4 mm. The compass is flattened and broad (viewed from above) in the outer part, but inward from the cross-fracture becomes compressed and narrow. This feature has probably been exaggerated by crushing.

The bifurcation of the outer end is not very marked, although the prominences project laterally to a considerable amount. The most striking features in the compass are the supports for the circular muscle. These project even further outwards than the external supports, as shown in Fig. 4. As far as I am aware, no such prominence in this region of the compass is met with in any other Echinoid, fossil or recent—in fact, the usual articulation for the circular muscle is rather a depression than an elevation. The compass of *Pholidechinus* (Jackson, loc. cit., pl. xxvii, fig. 5) shows nothing comparable, but is not very perfectly preserved. That of *Archæocidaris rossica* (loc. cit., pl. xii, figs. 1, 2) is particularly slender and smooth in outline.

The precise function of the circular muscle is not known. It is therefore idle to speculate as to the reasons for this extraordinary development in the compass of *Perischodomus.* It suffices to record that it is unique among known forms.

Tooth.—A small fragment of the distal end of a tooth is shown on the specimen. It is 5·8 mm. long (as far as exposed), and 4·25 mm. broad before it begins to taper. It is, as usual, Aulodont in character, and the groove is shallow. The point is broken away.

The specimen is now in the Manchester Museum, registered No. L. 8722.

V.—*Helminthochiton æquivoca*, n.sp., Lower Ordovician, Bohemia.

By Guy C. Robson, B.A.

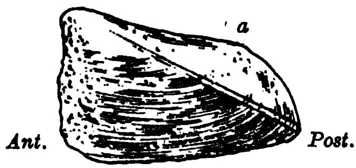
(Published by permission of the Trustees of the British Museum.)

THE species described in this paper is based on specimens acquired for the Geological Department of the British Museum in 1912 from Professor C. Klouček, of Prague, who collected them from the upper portion of $D_1\gamma$ (=Arenigian) at Šárka and Malé Prilepy. The fossil was referred in the first instance by Professor Klouček to "Chiton sp.?" and the result of the present investigation has been to uphold the reference to the Polyplacophora, though the precise generic status must remain vague.

The remains themselves consist of a number of imprints of shell-fragments in portions of two separate ironstone nodules, and have been studied by means of gutta-percha squeezes. In the nodules the imprints are arranged in a crude linear series of indeterminate form, while several of them lie apart from the main series. Two only have the appearance of being applied to one another in the characteristic Chiton fashion. A large number of the fragments are too amorphous to justify the expenditure of time in studying them. We therefore direct attention to six pieces, the shape and texture of which are sufficiently well characterized to enable one to form an opinion of their nature. These, however, are in no case connected with each other, nor do they afford any grounds, save those of general resemblance, for referring them to the same individual.

A typical fragment would consist of a single plate bent into halves, at an angle of 90° or less, along a line occupying the sagittal axis. At their line of junction the two halves form a sharp carina, while at one end of the plate the outer angles of the sides are produced, leaving a median V-shaped notch or emargination. There is probably a corresponding median projection at the other end, but of this it is impossible to be certain. On the surface of the plates a diagonal sculpture is seen extending as two or three faint grooves from the carina at one end to the free angle at the other (emarginate) end. Under a moderate power of the microscope, but scarcely visible with a hand lens, a faint concentric striation, like growth-lines, is visible running parallel to the outer margins. The valves themselves are very small, a typical example measuring 5 mm. along the carina, and 3·5 mm. from the carina to the inferior free border.

It is impossible to distinguish any other characters than these. Thus it will be seen that the data available for determining the nature and affinities of this fossil are very scanty. The bent plates with diagonal and concentric sculpture suggest a Chiton more than any other form, and we shall see that one character at least—the (posterior) emargination—suggests a definite genus of Chiton. One or two of the plates look superficially like the carinals of an unornamented Cirripede, though there is nothing beyond the carination to endorse this view, and Messrs. Cowper Reed and Withers have not upheld it after examining the specimens.



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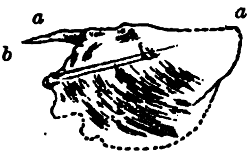
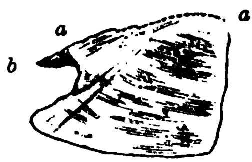


1.



3.

Helminthochiton æquivoca. × 6. Lateral view of plates. *a—a*, median line; *b*, the posterior emargination.

Reference to the literature of Ordovician and Silurian invertebrata has yielded only one genus to which this fossil might be referred, viz. Salter's *Helminthochiton* (1846–7) as redefined by de Rochebrune (1883). Through the kindness of Mrs. Robert Gray and Dr. R. F. Scharff it has been possible to make a careful study of *H. grayiæ*, Woodward (1885), from the Starfish Bed of the Drummuck group of Girvan (Ashgillian age), and of *H. griffithii*, Salter, from the Silurian (Upper Llandovery) mudstones of Galway. The type of the latter from the National Museum, Dublin, was lent by Dr. Scharff, while ample material representative of the former was lent by Mrs. Gray.

The Bohemian fossil seems to be adequately distinguished from the Girvan form. The only feature in common between them is the nature of their sculpture. But while in *H. grayiæ* both the concentric and diagonal markings are prominent and clearly defined, in the Bohemian form they are very faint and almost imperceptible, and withal very different in character. Indeed, with regard to *H. grayiæ*, Mr. Cowper Reed's doubts (1907) as to its true zoological position seem fully justified, and one would not be in any way surprised if it were to be at a future date removed from the Amphineura altogether.

On the other hand, there is a significant point of agreement between the Bohemian fossil and *H. griffithii* in the (posterior) excavation above alluded to. In addition the valves are short and deep in both species. On these grounds the new form may provisionally be placed in the same genus as *H. griffithii*. It is distinguished from that species by the possession of concentric and diagonal sculpture, and the more acute angle which the two halves of each plate form with each other.

So far as I can discover, no Chiton has been recorded from the Lower Ordovician before. Billings' problematic *Chiton canadensis* (1865) is apparently the oldest-known member of the family up to the present. This form was obtained from the Black River Limestone of Llandeilian age (= Middle Ordovician). If *H. æquivoca* should retain the classificatory position here assigned to it, it will rank as the oldest-known representative of the Amphineura.

The early Palæozoic Chitons would appear to have been small animals, possessed of an armature of thin valves, probably lacking insertional laminæ. In addition some of them were devoid of sculpture on most of their valves, while others (*canadensis*, Billings, the Silurian *bohemica*, Barrande, and the present one) were adorned at least with a sculpture of fine striæ. Differentiation into dorsal and lateral areas was scarcely marked, and a well-developed carina was probably present.

In conclusion, the author wishes to express to Dr. F. A. Bather, F.R.S., and Mr. F. R. Cowper Reed his acknowledgment of their valuable assistance.

Helminthochiton æquivoca, n.sp.

Valves minute, strongly carinate in the median line, (posteriorly) markedly emarginate, lacking insertional laminæ, subquadrate. Sculptured with two or three diagonal grooves, and with numerous fine concentric striæ running parallel to the free edges. Lower Ordovician, $D_1\gamma$ (= Arenigian), of Bohemia. Holotype in the Geological Department of the British Museum (G 22212), from Malé Prilepy. Paratype (G 22213) from Šárka.

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—— Quart. Journ. Geol. Soc., vol. iii, pp. 48–52, 1847.
H. Woodward, Geol. Mag., 1885, pp. 352–8.

VI.—The Petrology of Arran.

By G. W. Tyrrell, A.R.C.Sc., F.G.S., Assistant to the Professor of Geology, University of Glasgow.

1. The Riebeckite-orthophyre of the Holy Isle.—Four occurrences of acid and sub-acid igneous rocks containing the rare soda-amphibole riebeckite have been recognized in Great Britain, of which that of Ailsa Craig is the best known. The occurrences of Ailsa Craig[1] and Mynydd Mawr, Carnarvonshire,[2] are riebeckite-microgranites or paisanites. They contain ragged moss-like areas of riebeckite, together with microphenocrysts of quartz and alkali-felspar, in a microcrystalline groundmass of quartz and felspar. Riebeckite was also found by Dr. Teall in the granophyre of Meall Dearg and the neighbouring area of Druim an Eidhne, Skye.[3] Harker described the riebeckite in these rocks as occurring in two forms, one having the usual ragged, sponge-like appearance, and the other being idiomorphic, the faces in the prism zone being well-defined, but with irregular terminations.[4] The fourth occurrence differs somewhat from the others. This rock occurs as an intrusion into the Upper Old Red Sandstone, or Calciferous Sandstone of Easter Eildon Hill, Melrose, and was described by Barron as riebeckite-trachyte or phonolite.[5] It consists principally of sanidine, occurring both as microphenocrysts and in the groundmass, with interstitial patches of riebeckite, and a little nepheline. Harker describes the rock as an orthophyre.[6]

It is interesting to be able to add a fifth occurrence of a riebeckite rock in the so-called felsite of the Holy Isle, near Lamlash, Arran. It is noteworthy that Ailsa Craig is only 18 miles from this locality. The Holy Isle forms a steep and rugged conical hill rising to a height of 1,030 feet, and fitting, so to speak, at a distance of 1½ miles, into the recess of Lamlash Bay. It is a prominent landmark in the Firth of Clyde, as prominent almost as Ailsa Craig itself, and moreover of much the same shape. The island is extended in a N.N.W. to S.S.E. direction for 2 miles, and has an average width of half a mile. According to the Survey memoir and map of this district the Holy Isle consists of thick sills of felsite intruded into the third group (red sandstones and conglomerates) of the Lower Trias.[7] The latter occupies a narrow strip on the western and southern sides of the island, and is also intruded by a dolerite mass which forms a continuation of the Kingscross sill and by basalt dykes. The felsites, however, are probably later than the dolerites and basalts. According to the memoir they belong to the group of felsite sills, which seldom show free quartz and are usually non-porphyritic. These are believed to be later than

[1] Teall, Min. Mag., ix, 219–21, 1891.
[2] Harker, *Bala Volc. Ser. Carnarvon*, 1889, pp. 50–2.
[3] Q.J.G.S., l, 219, 1894.
[4] *Tertiary Igneous Rocks of Skye* (Mem. Geol. Surv.), 1904, p. 158.
[5] Geol. Mag., 1896, p. 376.
[6] *Petrology for Students*, 4th ed., 1908, p. 129; see fig. 33b, p. 128.
[7] *The Geology of North Arran, South Bute, and the Cumbraes* (Mem. Geol. Surv.), 1903, p. 70.

the contrasted group of quartz-porphyries, since they intrude the latter and are seldom pierced, as the quartz-porphyries are, by the ordinary basalt dykes.[1] In several places the 'felsite' of the Holy Isle forms great vertical cliffs showing a rude columnar jointing. On the western side of the island the igneous rock clearly rests on horizontal red sandstones and has a sill-like appearance.

The rock composing most of the island is a compact, hard, greyish, 'felsitic' material, which weathers deeply with a yellowish crust. On breaking open one of the large, loose, angular blocks which strew the slopes, a very regular concentric distribution of colour, due to gradations of alteration, is seen. The exterior yellow zone of decomposed material is often an inch thick, and, with regular gradations of colour, passes into fresher and fresher rock, and ultimately into a kernel of quite fresh rock. The latter is very compact, dark grey in colour, and shows minute, flashing cleavage-plates of sanidine. The rock frequently breaks into angular tabular fragments conditioned by a close horizontal jointing, and on steep slopes illustrates the formation of screes on a small scale to perfection.

Microscopically the rock consists of microporphyritic sanidine in a groundmass of smaller lathy crystals of the same mineral, with riebeckite and minute specks of iron-ore. The sanidine occurs in euhedral, rectangular, simply-twinned crystals, which are evenly and numerously scattered all over the field. The groundmass consists of subhedral laths of sanidine, closely packed together, with abundant riebeckite. The latter appears to occur in two forms, as in the Beinn Dearg granophyre. One set is in small independent prisms, parallel-sided in the prism zone, but with ragged irregular terminations; the other occurs in the well-known ophitic, mossy, or sponge-like masses. The latter are generally altered to an indeterminate yellow mineral, but the prismatic crystals are quite fresh and show the usual pleochroism from indigo-blue, through greenish-blue, to yellowish-green. Search was made for nepheline, but microscopic and staining methods failed to reveal any trace of this mineral.

The small laths of the groundmass show some approach to flow-orientation, but the numerous, short, stumpy, rectangular prisms of sanidine, dispersed in all directions throughout the rock, determine the texture as orthophyric. This, together with the intrusive mode of occurrence, renders the term riebeckite-orthophyre more appropriate than riebeckite-trachyte.

The rock differs from that of Ailsa Craig in being entirely devoid of quartz, which occurs both in the groundmass and as micro-phenocrysts in the latter rock. It is curious that these two islands, so similar in general appearance, should both be composed of riebeckite-bearing rock. If it were possible to examine the contacts of the Ailsa Craig mass, it is not improbable that it would be found to have geological relations similar to those of the riebeckite-orthophyre of the Holy Isle. The closest petrological affinities of the Holy Isle rock, however, are with the riebeckite-phonolite or

[1] *Geology of North Arran*, etc., p. 91.

orthophyre of the Eildon Hills, Melrose. The latter differs only in its somewhat coarser grain, and in the abundance and large size of its areas of riebeckite.

2. Crinanites of Whiting Bay and Dippin.—The crinanites are ophitic olivine-analcite-dolerites occurring as dykes in many parts of Argyllshire and the Western Isles. They are so called from Loch Crinan, which lies almost in the centre of their area of distribution.[1] They are closely associated with olivine-dolerites which differ from them only in the absence of analcite, and also with the remarkable monchiquites and camptonites which have recently been described from Colonsay and Mull. Complete descriptions of this suite of dykes have been given by Dr. J. S. Flett in recent Survey memoirs, and chemical analyses have been made in the Survey laboratory.[2]

These dykes have the north-west trend so common in the Tertiary suite of the Western Isles and the adjacent mainland. Their unusual petrological character, however, has rendered their connexion with Tertiary igneous activity of some dubiety. In the south of Mull a few undoubted Tertiary dykes of analcite-dolerite have been found, and Mr. Wright has found analcite-dolerites amongst the north-west dykes of the Beinn Dearg group in Skye.[3]

The crinanites show transitions to the camptonites in their type-locality, and also have many resemblances to the Carboniferous teschenites which are common in the Midland Valley of Scotland. Dr. Flett, however, enumerates four differences: they are finer in grain than the teschenites, have a perfect ophitic texture, hornblende and biotite are scarce, and they occur as thin, vertical, parallel dykes instead of sills.[4] One might add that in general they are much richer in olivine than the teschenites, but poorer in analcite and alkali-felspars. These mineralogical differences are clearly brought out in a comparison of the chemical analyses of the two rocks. The teschenites are much richer in alkalies and combined water, but considerably poorer in ferrous iron and magnesia.[5]

The present paper records the occurrence of a dyke of crinanite at Whiting Bay in the south-east of Arran, and also records that the great sill of Dippin, hitherto regarded as a teschenite, is much closer in its affinities to crinanite. The sills of Kingscross and of the Clauchland Hills are also to be regarded as crinanites. All these rocks intrude the Triassic sediments, and are most probably of Tertiary age. The Arran occurrences thus furnish one more link in the chain of evidence which connects the crinanites and the associated monchiquites and camptonites of the type-locality of Argyllshire with Tertiary igneous activity.

[1] *Summ. Prog. Geol. Surv. for 1909*, 1910, p. 52.

[2] *The Geology of Knapdale, Jura, and North Kintyre*, 1911, pp. 116–18; *The Geology of Colonsay and Oronsay, with Part of the Ross of Mull* (Mem. Geol. Surv.), 1911, pp. 41–6.

[3] *The Geology of Colonsay and Oronsay*, 1911, p. 41.

[4] *The Geology of Knapdale, Jura, and North Kintyre*, 1911, p. 117.

[5] For analyses of teschenites see *The Geology of the Neighbourhood of Edinburgh* (Mem. Geol. Surv.), 1910, p. 299.

Petrography.—On the shore of Whiting Bay and at Kingscross Point are numerous rounded pebbles and boulders of a fresh doleritic rock which is rendered prominent by a distinct spotting of rounded lighter areas on a darker ground. Ultimately this rock was traced to a thick dyke penetrating the Triassic sandstones on the shore of Whiting Bay, a little to the north of the School.

In thin section the rock is seen to consist of an ophitic plexus of plagioclase and augite, in which the former is largely predominant. Fresh olivine is very abundant, and a skeletal or platy ilmenite only less so. Analcite or a fibrous radiating zeolite fills many of the polygonal interspaces between the felspar laths. The plagioclase is euhedral and zonal, the composition ranging from acid labradorite ($Ab_1 An_1$) in the interior to oligoclase ($Ab_4 An_1$) in a thin marginal zone. As usual, the undulose extinction due to zoning is very prominent in untwinned sections cut parallel to the clinopinacoid. The augite is a deeply-coloured purplish variety, with a pleochroism ranging from deep purplish-brown to a pale sepia, and is probably rich in titanium oxide and alkalies. It is very subordinate in quantity to the plagioclase, and is cut up by the latter into thin strips and small triangular or polygonal patches. The abundant olivine is very fresh, or at most has suffered only incipient serpentinization, and occurs in small, more or less rounded, subhedral granules, which are frequently enclosed along with ilmenite in the plates of augite. Turbid but still isotropic analcite fills up many of the straight-sided interspaces between the felspars. In some cases, however, the spaces are filled with a low-polarizing, radial zeolite, whose optical characters agree with those of scolecite. The ilmenite is mostly skeletal, but sometimes occurs in long thin plates or rods, which are enclosed in and earlier than the titanaugite, but frequently mould the terminations of felspar laths. Occasionally small scraps of red biotite are associated with the iron-ore. The spotting visible in the hand specimen is due to a comparative scarcity of the ferromagnesian minerals in certain areas, and is only recognizable with difficulty in thin section. From this description it will be evident that this rock is identical with crinanite. I have been able to confirm the identification by comparison with slides of typical crinanite from Argyllshire kindly lent by the Geological Survey.

The great sill of Dippin which has been described by Corstorphine as olivine-analcime-diabase,[1] and by Harker as teschenite,[2] appears to me to be more nearly related to crinanite. It agrees with the latter in the perfect ophitic relations between augite and plagioclase, and in the abundance of fresh olivine, both of which characters are very unusual in the teschenites. In many specimens (e.g. from the north end of the Dippin cliff) the interstitial analcite is not at all prominent. Only in some outcrops in Glen Ashdale does the analcite become as abundant as in the teschenites. The mass of the Dippin rock, however, is much coarser in grain than is usual with the typical crinanites, but this, of course, is conditioned by its mode of occurrence

[1] *Tscherm. Min. Petr. Mitth.*, xiv, 463–5, 1895.
[2] *The Geology of North Arran, South Bute, and the Cumbraes* (Mem. Geol. Surv.), 1903, pp. 112–14.

in thick sills. Near the contacts the Dippin rock becomes identical with crinanite even in the matter of grain-size.

The sill of Kingscross Point must also be correlated with the Dippin sill and with the crinanites. It differs from the Dippin rock in carrying a much smaller quantity of interstitial analcite and zeolites and in a finer grain-size. The felspars are approximately equal to the titanaugites in bulk, but the individual crystals are much smaller. The ophitic plates of titanaugite are pseudo-porphyritic in a groundmass composed of closely packed laths of plagioclase. The Kingscross sill has suffered a curious veining by a tachylytic basalt, and has also developed pegmatitic variation-facies in which analcite and other zeolites are very prominent.

From Allport's description it is probable that the great sill which caps the Clauchland Hills is also a crinanite. He says: "A typical specimen from Dun Fion contains crystals of plagioclase beautifully striated, augite and olivine in a remarkably fresh condition, magnetite, a few plates of brown mica, a little apatite, and a clear amorphous glass in the interstices of the constituents."[1] The "clear amorphous glass" is almost certainly analcite.

All the rocks described above are unquestionably Tertiary in age. Very similar rocks, however, are to be found amongst the alkalic Late Carboniferous or Permian eruptives of Ayrshire.[2] Most of the rocks of this sub-province which are to be regarded as related to crinanite are intrusive in the Permian sandstones and underlying lavas of the Mauchline basin, and are associated with analcite-syenite. A good crinanite from an intrusion at New Gilston, Fifeshire, has recently been brought to my notice by Miss A. T. Neilson, of the Hunterian Museum, University of Glasgow.

REVIEWS.

I.—Geological Survey Memoir.

The Geology of the Lizard and Meneage. By Dr. J. S. Flett, M.A., and J. B. Hill, R.N. 8vo; pp. viii, 280, with 15 plates and 10 text-illustrations. London: printed for His Majesty's Stationery Office, 1912. Price 5*s*.

MENEAGE, as we are told in the preface to this memoir, is an old Cornish name for the Lizard promontory, south of the Helford River; so that the name applies to the whole of the Lizard area, but strictly speaking not to the northern margin in the Geological Survey map, which includes Rosemullion Head on the east and Breage on the west. The colour-printed map (Sheet 359) shows clearly the line of demarcation between the igneous and metamorphic Lizard Series and the mainly sedimentary series, which in old days was known generally as 'killas'. This forms the northern portion of the area, together with some intrusive and interbedded igneous rocks, including a fringe of granite at Constantine and a small tract at Breage. The two great rock-series appear to be

[1] Q.J.G.S. xxx, 563, 1874.
[2] Tyrrell, Geol. Mag. (V), IX, 124, 1912.

separated by a fault or thrust-plane, heading to the south and south-east, and carrying well-marked breccia. The disturbance is well shown near Polurrian Cove on the west and near Porthallow Cove on the east, but it cannot be definitely traced throughout the intermediate ground.

The southern area has been mapped and described by Dr. Flett, the northern by Mr. Hill. The entire region is a somewhat irregular plateau, averaging about 280 feet in elevation, but rising on the serpentine of Goonhilly Down to 370 feet, and on the hornblende schist of Roskruge Beacon, west of Porthallow, to 378 feet. This plateau, eroded to a great extent probably in Miocene and early Pliocene epochs, was further planed down in later Pliocene times, when the area was submerged to the extent of about 420 feet. Relics of gravels regarded as of Pliocene age (but not fossiliferous) occur on the gabbro of Crousa Common north of Coverack.

The coastline in general is rugged and rocky, and often difficult of access, but characterized by numerous highly picturesque coves, while the broad tidal waters of the Helford River and the Loe valley south of Helston are bordered by wooded slopes of great beauty. The region in general is described as essentially an agricultural and not a mining country, and in this respect it compares with the metamorphic area of Salcombe in South Devon, which is included in the fertile district of the South Hams. In the Lizard the least cultivated portions are on the serpentine, which yields a thin clayey soil, liable to be waterlogged, and the land is comparatively barren and dreary.

A full, and in all respects excellent, account of the previous literature relating to the Lizard Series is given by Dr. Flett, and it is interesting to read of the gradual progress of knowledge and of the diverse views concerning the origin and relations of the rocks in this complex area. To the elucidation of the problems Professor Bonney, Dr. Teall, Mr. Howard Fox, Mr. Harford J. Lowe, also the late General McMahon and Alexander Somervail, have been the principal contributors. It has remained for Dr. Flett to examine in detail the entire area and bring the experience gained by seeing the whole of the evidence to the interpretation of the mineral changes in the rocks, their sequence, and structural features; and it may be affirmed that as complete a story as possible has been unfolded by the masterly way in which this petrographical area has been investigated. The one point on which we fail to find definite expression of opinion is that of the geological age of the Lizard rocks, though it may be inferred that Professor Bonney's reference of the mica schists to the Archæan is not contested by Dr. Flett, who regards the Old Lizard Head Series as "an important part of the Lizard schists".[1] Moreover, the intimate connexion of the series appears manifest when we read that "in 1893 Somervail advanced the hypothesis that all the principal rocks of the district, the hornblende schist, serpentine, gabbro, black dykes, and banded gneisses, were differentiated from one magma. As he had already arrived at a correct conception of the sequence of these rocks, he may be regarded

[1] See also Flett's account of "The Geology of the Lizard" (Proc. Geol. Assoc., xxiv, p. 118, 1913).

as the first to solve one of the most fundamental, and at the same time most obscure, problems of Lizard geology".

With regard to the vexed subject of fluxion banding and foliation, it is remarked that "in the plutonic and intrusive rocks of the Lizard there is a foliation intimately connected with the injection of the igneous magma, but it is clear also that earth-movements were going on at the same time. The most important fact to bear in mind is that the igneous rocks can be shown to have attained their present metamorphic state as soon as, or very shortly after, they had consolidated".

The following sequence, in descending order, is recognized by Dr. Flett:—

Granite and Granite Gneiss.
Kennack Gneisses (banded).
Dolerite and Epidiorite dykes.
Gabbro (with augen gabbro and gabbro schist).
Troctolite.
Serpentine (Bastite, Tremolite, and Dunite varieties).
Hornblende schists: Traboe schists.
Treleague Quartzite.
Man of War Gneisses.
Hornblende schists: Landewednack schists.
Old Lizard Head Series { Green schists. Granulites. Mica schists.

It is pointed out that sedimentary rocks are represented by the mica schists, granulites, and Treleague quartzite; and that the varieties of serpentine pass one into another, the dunite variety being the marginal facies, the tremolite serpentine adjoining it, and the bastite variety or lherzolite being the central rock.

In separate chapters full particulars are given of the subdivisions of the metamorphic rocks of the Lizard Series.

Turning now to the northern series of rocks, we find the sedimentary Mylor, Falmouth, and Portscatho Series of Mr. Hill, grouped as Ordovician (?), although as they presumably underlie the Veryan Series regarded as of Llandeilo or Arenig age, and "probably Arenig", the three former series may include rocks that are pre-Ordovician. Only the Veryan Series has yielded fossils, and with it are grouped the Radiolarian cherts of Mullion Island. Lower Devonian is recognized in the Manaccan Beds, which consist of slate, sandstone, and conglomerate, with fragments derived from the Portscatho and Veryan rocks. The sequence maintained by Mr. Hill has, however, been contested by Mr. Upfield Green and Mr. C. D. Sherborn, who, in their latest grouping, place the "Dartmouth, Falmouth, Ladock, Grampound, Manaccan, Mylor, Portscatho, and Veryan" Beds in the Lower Devonian (Gedinnian); and they apply the term Veryan to "beds containing lenticular inclusions yielding Ludlow, Wenlock, and Woolhope fossils", placing them beneath the Manaccan Beds and above the Ordovician quartzites of Gorran.[1] There does not appear to be any justification for this application of the term Veryan, as it strictly belongs to the strata (thin limestones, Radiolarian cherts, slates, quartzites, and pillow-lavas) grouped by Mr. Hill as Ordovician.

[1] See GEOL. MAG. for 1912, p. 560.

The important discoveries of Silurian (Ludlow) fossils made by Mr. Green and Mr. Sherborn in "Black slates with limestone lenticles" at Fletching's Cove near Porthalla (Porthallow on map), and in the "Slates with inclusions" at Nare Cove, south of Nare Head, do not prove that the inclusions and lenticles are of a conglomeratic character and of Devonian age. In such a region of faulting and thrusting and probable infolding, it would seem more likely that the inclusions have been brought about by disturbance. The fact observed by Mr. Hill that the Manaccan conglomerate contains fragments of the Portscatho rocks, etc., does not appear to have been taken into consideration by Mr. Green and Mr. Sherborn, and this evidence strongly favours Mr. Hill's view that the Manaccan conglomerate forms the local base of the Devonian. It is to be hoped that these three geologists may be able in due course to harmonize their views. Materials for the definite determination of some of the problems are still wanting. It has been pointed out that the absence of any fragments of the Lizard Series in the Ordovician and Devonian rocks of the area is remarkable, and cannot be satisfactorily explained; and there are features that have led Mr. Hill to see evidence of a transitional passage from the Veryan group into the Lizard Series. The facts for and against this hypothesis are fully discussed in the memoir, wherein it is stated "that this difficult problem is not yet by any means settled".[1]

In thus referring to the chief controverted subjects, we have no space in which to enlarge on the accessions to knowledge in reference to the various igneous rocks and to metamorphism. It should be mentioned, however, that apart from the Lizard Series there are pillow-lavas (spilites), granite, elvans, and mica-traps in the northern area, and these are duly described. Some account is given of the possible derivation of the Gunwalloe beach-shingle from an old Eocene deposit, and then follow descriptions of the Pliocene gravels, raised beaches and head, submerged forests, and coast erosion. An interesting and instructive account is given of the soils and agriculture, followed by notes on the water supply, building materials, serpentine industry, and mining, to which last subject Mr. D. A. MacAlister has contributed.

The plates include excellent views of scenery, rock-structures, and photomicrographs of rocks, and among them is one of a "Glacial Boulder on the Beach at Porthleven". This, known as the "Giant's Rock", is a block, about 50 tons in weight, of "microcline gneiss of a type unknown in Britain", and has evidently been derived from the raised beach.

II.—Primitive Brachiopods.

Cambrian Brachiopoda. By Charles D. Walcott. Monographs of the United States Geological Survey, vol. li, part i, pp. 1–872; part ii, pp. 1–363; plates i–civ. 4to. Washington, 1912.

THIS immense work is another example of the wonderful energy of American scientific investigators, and is a further proof of their very comprehensive grasp of their subjects. Not alone the students

[1] See also Hill, Proc. Geol. Assoc., xxiv, p. 153, 1913.

of Palæozoic rocks, but all palæontologists and all evolutionists owe to the gifted author, Dr. Walcott, their cordial thanks for a monograph dealing so fully with the Brachiopod fauna which existed in those far-off days when the earth was yet in her youth.

Looking at these two fine volumes, with their testimony to careful scientific work on every page—these two volumes published by the United States Geological Survey, well printed and magnificently illustrated—one is doubtful whom to envy most, the scientific investigator who has not only the ability and the patience but also the time to execute such a task, or the Government which so ably places his results before the world. For publication is a very important factor. There is nothing more stimulating to any worker than to know that his task when accomplished will be adequately printed; there is nothing which undermines the worker's energy more than a doubt whether his work may ever see the light, while the feeling that it may in the end be mutilated or very inadequately presented on the score of expense is almost as fatal. Scientific workers in other countries, then, might be forgiven if they exclaim to Dr. Walcott, or to his Government, "Almost thou persuadest us to become Americans!"

What, however, of the contents of these volumes? To criticize them in detail would be futile. Dr. Walcott has made a life study of the faunas of the Cambrian rocks, and his expert knowledge is of worldwide reputation, proved and attested by many previous communications. The present monograph on the Cambrian Brachiopods of the world has occupied the author for the last ten years: that it has been accomplished in that space of time is a tribute to the author's untiring perseverance.

"This monograph includes the description of 44 genera, 15 subgenera, 477 species, and 59 varieties of Cambrian Brachiopoda, and of 3 genera, 1 subgenus, 42 species, and 1 variety of Ordovician Brachiopoda. . . . In this paper the Brachiopoda are treated in three ways—historically, geologically, and zoologically. Historically the treatment comprises (1) a bibliography and (2) a table of synonymic reference. . . . Geologically the distribution of the Brachiopoda is considered under the following headings: (1) General geographic and stratigraphic distribution; (2) detailed geographic distribution; (3) detailed stratigraphic distribution; (4) habitat; and (5) fossil localities. Zoologically the discussion covers (1) the physical characters of the Brachiopoda; (2) their distribution; (3) their evolution; and (4) their classification. Lastly come the detailed descriptions of genera and species and the illustrative plates" (p. 11).

The number of species of Cambrian Brachiopoda is remarkable; it is an interesting picture of how much development and differentiation had been accomplished even in those early days. Tables of Detailed Geographic Distribution are given in pp. 114 et seqq., but one misses a comparative analytical table of numbers of species in different regions. North America supplies by far the largest number —the species are some hundreds; but as a remarkable contrast South America is credited with only five species. Next to North America in point of numbers comes Europe with about a hundred species, but the British Islands can only boast about one-fifth of this total; the greatest number is provided by Scandinavia, including Finland. Asia yields about forty species and Australia six, but there can be little doubt that further exploration of these regions would increase the number.

This very elaborate monograph cannot fail to be of the utmost importance to the student of the Brachiopoda of the Palæozoic rocks. There is a bibliography extending to thirteen pages, and, what is always of the very greatest assistance to the worker, there is an exhaustive Table of Synonymic References—how exhaustive may be judged from the fact that it extends to about seventy pages; it is also testimony to the large amount of investigation, and the constant rearrangement in the light of further knowledge, which the Cambrian Brachiopods have received. That the present monograph exhibits the nomenclature in anything like a final form no one could pretend to hope, especially when it is considered how very obscure are some of these small fossils, and how difficult they are to interpret. But the energy which Dr. Walcott has brought to bear on the elucidation of his subject deserves our warmest thanks. America may well boast of the industrious, and, what is perhaps more important, of the very progressive investigators of Brachiopoda which she has produced, men who have given us what has almost seemed to be revolutionary work. James Hall and C. E. Beecher, Professor J. M. Clarke, Professor Schuchert, Dr. E. R. Cumings, and others form with the writer of the present monograph a band who have made our knowledge of fossil Brachiopoda, especially of the older formations, advance from comparative chaos to well-arranged order.

Considering the nature of the remains and the magnification so frequently required, the excellent plates are deserving of special commendation. Dr. Walcott says (p. 13): "the drawings have been prepared mainly by Miss Frances Wieser, of the United States Geological Survey. The plates are the evidence of her faithful work." They are; it is not only good work but a magnificent task. There are over a hundred plates, and the number of separate figures must run into several thousands, figures full of fine detail, all very carefully executed. Nothing more beautiful has been placed before the student of Cambrian Brachiopoda: perhaps if we said of any Brachiopoda it would not be incorrect.

There is a small matter connected with the plates—mainly an editorial matter—to which we would call attention. It is very desirable that all the explanation of each plate should appear in the one opening, opposite the plate. In view of the immense amount of literature, workers' time should be saved in every way, and reference to figures of a plate should be made as clear and easy as possible. But this cannot be where there is the too common fault of separating the explanation from its plate, or even, as in the work before us, carrying the explanation over to a leaf behind the plate. In many cases in the present work such carrying over has been quite needless, and all the explanation could have been placed on the facing page. In other cases the use of smaller type would have enabled the required position to be achieved. In yet other cases where even that expedient would have failed, a skeleton explanation printed at the top of the facing page, to be followed by the detailed explanation, would have been of great assistance.

Anything which lessens chances of misquotation and facilitates reference to a work makes that work, in our opinion, the more valuable. And frequent reference to such a work as this is to be desired, for the monograph thoroughly deserves it. We congratulate Dr. Walcott on the completion of a magnificent task, most worthily executed. It is another monument to his great abilities.

III.—Catalogue des Invertébrés fossiles de l'Égypte représentés dans les Collections du Geological Museum au Caire. Par R. Fourtau. Terrains tertiaires. 1ère partie: Échinides Éocènes. 4to; pp. 1–93, pls. i–vi. Le Caire. Gouvernement égyptien. Administration des Arpentages. 1913.

DURING the Cretaceous and Eocene periods the Echinoid fauna of the Mediterranean region seems to have been one of the richest known from any part of the world. In the case of the former period the wealth of species and individuals may probably be ascribed to the littoral conditions then prevalent in Northern Africa, where, perhaps in a tropical climate, shore-life must have been uniformly prolific. It might be expected that the relatively pelagic conditions which came in with the Tertiary epoch would have resulted in a reduction in numbers and variety; and, indeed, it may yet be a question whether the list of 130 species recorded from the Egyptian Eocene alone may not in some measure owe its length to excessive zeal in the separation of 'species'. This question seems the more appropriate when it is found that the genus *Schizaster* is credited with eighteen species and *Echinolampas* with nineteen!

In the study of the fossil Echinoids of the eastern part of the Mediterranean the mantle of de Loriol has fallen upon M. R. Fourtau, and he proves himself a worthy successor in the task of analysing the, as yet, fragmentary knowledge of the fauna. The present catalogue supplies a valuable résumé of past work on Egyptian Eocene Echinoids, and adds not a few new forms to the list.

Although the main work is necessarily purely systematic, the author gives an interesting 'apologia' in his Introduction. The methods of systematists often seem to date from the earlier half of last century, when, in the absence of any definite creed of evolution, the slightest differences between two specimens must needs lead to their specific separation. Although M. Fourtau adopts these methods in no small degree, he gives at the outset a confession of faith in the principles of the "Enchaînements du monde animal". He anticipates that, with fuller knowledge, it will be possible to unite many of the 'species' described in his catalogue into genetic series, but he regards all such attempts at present as being premature. He differentiates very properly between the zoological and stratigraphical conceptions of species, and reluctantly restricts his palæontology to its geological aspect.

For the purposes of a catalogue such a course is inevitable. But M. Fourtau suggests that in no other place would any but systematic work upon Egyptian fossil Echinoids be appropriate or even feasible. Surely 130 species from one formation represent sufficient material for philosophical consideration! Any phylogenetic grouping, however tentative and even inaccurate, would be more illuminating than a purely alphabetical arrangement of species. May we express the hope that M. Fourtau, with his unique opportunities and peculiar knowledge, will at some future time yield to his temptation to discuss rather than describe his specimens.

In the catalogue under consideration there seem to be more than the average number of misprints and other small inaccuracies. Misprints in dates are always dangerous, and on p. 83, under the heading of *Echinolampas ovalis*, there occurs a flagrant case. Would it not be a safeguard if new species were indicated as such in words, and not merely ascribed to the author with a date? In the present work new forms appear, ascribed to R. Fourtau under the varying dates of 1912, 1913, and even 1914! In one case (*Conoclypeus delanouei*, var. *macropyga*) the legend to the plate includes the words 'nov. var.', whereas in the text it is found that the variety was described in 1908! Surely the removal of such fruitful sources of confusion to later systematists is worth a little care in the proof-reading. A discrepancy in the title of the work, as engraved on the plates and as printed on the cover, is a further illustration of the unnecessary trouble that may be caused to future bibliographers.

In spite of the above criticisms of detail, the catalogue as a whole must be regarded as an invaluable contribution to our knowledge of Eocene Echinoids, and its publication would, of itself alone, assure M. Fourtau a high place among systematic Echinologists.

H. L. H.

IV.—Structure and Affinities of *Sutcliffia*.

A PAPER in the *Annals of Botany*,[1] by Dr. Ethel de Fraine, concerns a fragment of a petrified stem which was obtained from the colliery at Dearnley, near Littleborough. The specimen is of Lower Coal-measure age, and obtained from a nodule in the roof of the workings, probably from the same seam as the stem of *Sutcliffia insignis*, described by Dr. Scott (Trans. Linn. Soc. London, ser. II, vol. vii, pt. iv). The specimen was of large size, 9·5 by 3·5 cm. being the maximum transverse dimensions, while the total length of the fragment was about 25 cm. The structure presents considerable complexity, and consequently a model of the vascular tissues was constructed, in order to elucidate the behaviour of the strands. The main vascular axis consists of a solid central strand of wood (aprotostele), surrounded by leaf-traces of varying size (the 'meristeles'); a network of extra-fascicular bands of wood and bast encloses the stele and 'meresteles', while a zone of secondary cortex forms the limit of the specimen. The leaf-traces ('meristeles') pass out from the protostele without appreciable disturbance of its tissues, and are precisely similar to it; they divide up irregularly into smaller bundles, and are ultimately entirely used up

[1] Vol. xxvi, No. civ.

in the production of the small concentric foliar traces. Occasionally accessory concentric bundles are present, recalling the similar strands which occur in the cortex of *Cycas*. The vascular strands of all orders, except the ultimate foliar traces, are surrounded by a broad zone of secondary wood. On account of the general structure of the vascular system, the origin and behaviour of the 'meristeles', the leaf-trace bundles, and the close agreement in histological details (such, for example, as the pitting on the tracheidal walls), the stem is included in the genus *Sutcliffia* of the family Medulloseæ. It is provisionally attributed to *Sutcliffia insignis*, Scott, for the additional features which are characteristic of the specimen are such as would be expected to occur in an older stem: such features are the occurrence of secondary wood, the extra-fascicular strands, the secondary cortex, and the absence of leaf-bases.

The specimen is of some importance on account of the additional light which it throws on the affinities of the extinct family of the Medulloseæ. The great possibility of the origin of this group from a fern-like ancestry has been fully considered elsewhere, and many investigators have regarded it as the source of origin of the Cycadaceæ. The discovery of the present stem adds considerable weight to this view, for in many respects the structure is of a distinctly Cycadean type. It is suggested that by modification of the protostele and elaboration of the extra-fascicular zones of some such genus as *Sutcliffia*, the Cycadaceæ were evolved; while, on the other hand, increasing complexity in the number and arrangement of the steles may possibly have led through such a type as the English *Medullosa anglica* to the complex Permian Medulloseæ.

V.—Fossilium Catalogus. I. Animalia. Editus a F. Frech. Pars 1: F. Frech, Ammoneæ Devonicæ (Clymeniidæ, Aphyllitidæ, Gephyroceratidæ, Cheiloceratidæ). 4to; pp. 42. Berlin: Junk, 1913. Price 4 marks.

THIS seems to be just one of those works whose usefulness fails because the compiler refuses to adhere to a strictly alphabetical arrangement. So splendid an example of what an Index Palæontologicus should be was bequeathed to science by H. G. Bronn that it is difficult to comprehend the mind of those who spend their time on a systematic arrangement which in nearly every case can only be of service to the narrow specialist, and little indeed to him, for he already knows his subject. Further, why limit the references to Devonian forms? There is already much grumbling among those who have to consult the three or four indexes extant for generic names and a request that they may all be thrown into one, but in this proposed work we are threatened with a separate index not merely to each group but to each geological horizon of the families of the group.

In the work itself we consider that a date should be attached to *each* entry. We note the twenty-nine titles quoted do not represent the complete literature; we do not understand on what authority the name *Agoniatites*, Meek, is rejected for *Aphyllites*, Mojs.; and we hope "Mopisovus" on p. 25 will be intelligible to the uninitiated.

If our German friends would organize a staff and get another 'Bronn' ready for the next generation they would be doing a real service to Palæontology, but we honestly think that work published in parts in this way is of little or no service to the real worker, especially when it is arranged in systematic and not alphabetical order. It is never wise to introduce into a reference book any personal idiosyncrasies.

VI.—The Earth: its Shape, Size, Weight, and Spin. By J. H. Poynting, Sc.D., F.R.S. 8vo; pp. 141, with 49 text-figures. Cambridge: at the University Press, 1913. Price 1*s*. net.

DIFFERENT branches of geology have been dealt with in previous volumes of this enterprising series, and Professor Poynting's little book is concerned with the earth from a physical aspect. There are only three chapters, and their simple-sounding titles are: "The Shape and Size of the Earth," "Weighing the Earth," and "The Earth as a Clock." In telling the story of the growth of the idea of a round earth, the author would take us to the top of a hill on a clear day to look over a stretch of lowlands, where we might with the ancients conclude there was nothing to suggest that the earth is not flat. In our first chapter we are told how a different conception of the earth's form came into being, and how Columbus proposed to reach India by sailing to the west. A few simple figures and some easy calculations are given in support of the modern view, and these are followed by a description of the method of measuring distances on the earth's surface. The base-line method of measuring is illustrated also by an account of the finding of the distance of the nearer stars.

In beginning his second chapter the author illustrates clearly the relationship between the weight and mass of the earth. We then read of the earth-weighing experiments—the early ones of Newton, Bouguer, Maskelyne, and Cavendish, and the later and more delicate one of Professor Boys. When considered as a clock, our planet is regarded, of course, as whirling round the sun, and we see how the spin of the cyclones is connected with this movement. The principle of Foucault's pendulum is also dealt with. But by far the most interesting topic is that of the tides, which are treated in connexion with Sir George Darwin's discoveries. It is shown that the tides are gradually reducing the earth's spin, that the action of the moon on them is gradually lengthening the day, and the reaction of them on the moon is lengthening the month. The same reckoning points to the probability of the moon and the earth forming the same body in the past, and the likelihood of the moon's ending her journey by reunion with the parent globe in the far-distant future.

VII.—Effects of Pressure and Temperature on Rock-formation.

GEOLOGICAL speculations on matters connected with the formation of rocks have often been founded on misunderstood or misinterpreted experiments. Mr. John Johnston and Mr. L. H. Adams, in a paper on the effect of high pressures on the physical and chemical behaviour of solids, published in the number of the *American Journal* *of Science* for March, 1913, have done good service by collecting and critically discussing the available data. They point out that a non-uniform pressure, i.e. one involving a shear, is an incomparably more effective agency than a uniform pressure, which is not so important as a high temperature.

VIII.—On the occurrence of Nepheline in Phonolite Dykes at Omeo. By Professor E. W. Skeats. Section C: pp. 126–31, with one plate. Australasian Association for the Advancement of Science, 1912.

THIS paper gives a list of previous records of felspathoids in Victoria, and shows that most of these have been due to incorrect determinations. The author corrects his previous record of nosean and melilite in the alkali rocks of Mt. Macedon.

A brief sketch of the geology of Omeo, Eastern Gippsland, is given. Granites and quartz-diorites are intrusive into pre-Ordovician or pre-Cambrian schists, and there is a group of anorthoclase-trachytes and solvsbergites, which are younger than the plutonic rocks. Another group of dykes occurs at Omeo, and the phonolite dykes here described are the youngest in this area.

The rocks are described in detail, and the percentages of alkalies in one rock have been determined. The mineral composition is: soda-orthoclase 46, nepheline 28, and ægirine 25 per cent. A mineral occurring interstitially between the felspars is referred provisionally to cancrinite.

IX.—Canada.

Geological Survey of Canada.

(A) In Memoir No. 17E (1912) is an account of the "Geology and Economic Resources of the Larder Lake District, Ont.", by Mr. M. E. Wilson. The formations shown on the map are Keewatin (greenstone and various schists, slate, dolomite, quartz-porphyry, and rhyolite), Pontiac schist, Laurentian (granite, gneiss, etc.), Huronian (conglomerate and greywacke), Post Lower Huronian (diabase, etc.), and Pleistocene and Recent deposits. The mineral products include gold, silver-lead, copper, cobalt, nickel, molybdenite, and iron. The report contains interesting views of scenery and rock-structures.

(B) Memoir No. 35 (1912) gives the results of a "Reconnaissance along the National Transcontinental Railway in Southern Quebec", by Mr. J. A. Dresser. The rocks described include Cambrian, Ordovician, Devonian (igneous), and Drift. The district has been glaciated from the N.N.W., and the rock surface is generally, and in places heavily, covered by soil. Stratified Drift deposits of clay, sand, and loam occur in the lowlands and in some of the upland valleys. The mineral prospects are not of great promise. Small quantities of asbestos, chromite, chalcopyrite, and bog iron-ore occur; there is slate of good quality, also quartzite, and peat-bogs. Much of the district is suitable for farming, and part for lumbering. Among the illustrations there is a striking view of the St. Lawrence lowland.

(C) Department of Mines, Canada: Mines Branch, 1912.

Pyrites in Canada. By A. W. G. Wilson. pp. xi + 202, with 27 plates, 26 tables, 29 figures in the text, and 1 map.

This report, while outlining the pyrites resources of Canada, has for its object the promotion of a further development of these resources. It is pointed out that, if a steady supply of a uniform grade of ore were assured, more than four times the present production in Canada of this ore would find a ready market. This market might be still further increased on account of the rapid expansion of the sulphide pulp industry in Canada.

The book gives a short account of the chemical and physical properties of the chief sulphur ores, and notes on the mining and marketing of pyrites. The statistics of the production of pyrites are given in fifteen tables.

The occurrence of pyrites in Canada is treated at length, some forty prospects being described. This chapter is illustrated by an admirable series of photographs and by a map showing the positions of the pyrites deposits in Eastern Canada. The same chapter contains descriptions of the pyrrhotite at Sudbury, Ontario, and of the famous pyrites deposits of Huelva, Spain, and of Norway and Japan.

The remaining chapters deal with the roasting of pyrites, the manufacture of sulphuric acid, and the importance of pyrites to the paper-manufacturing industry. Appendices give a list of firms interested in Canadian pyrites, types of furnaces used for burning sulphur, a discussion of the use of pyrrhotite as a sulphur ore, and of the contact process for the manufacture of sulphuric acid.

The book is most profusely illustrated. It contains a fund of information of a highly practical nature which must prove invaluable to those actively engaged in the production of pyrites, while its less technical matter cannot but appeal to those interested in the scientific aspects of pyrites deposits.

(D) Mineral Production, Canada, 1911–12.

(1) A general summary of the mineral production of Canada during 1911.
(2) Preliminary report on the mineral production of Canada during 1912. By J. McLeish.

The decrease in mineral production of 1911, as compared with 1910, is attributed largely to the strike of coal-miners in Alberta and in the Crowsnest district of British Columbia. The preliminary report for 1912 shows an increased production for every important mineral mined with the exception of petroleum. The working of the nickel-copper ores of the Sudbury district of Ontario in 1912 shows a greatly increased output. Small shipments of nickel ore were also made in 1912 from the Alexo Mine at Kelso in the Nipissing district.

(E) Geological Survey, British Columbia.

Map 62A (to accompany Memoir 34). Nelson and vicinity, West Kootenay, British Columbia.

A geological and topographical map of an area of about 120 square miles, on the scale of 1 mile to the inch, with contours at intervals of 250 feet. It is based on the map published in 1904, and gives the relations of the Nelson batholith (granites, monzonites, and quartz-diorites) and its accompanying dykes to the rocks of the Rossland and Pend d'Oreille groups (? Carboniferous).

X.—Professor Doelter's Mineralogy.

THE first part of a second volume of Professor Doelter's great work (*Handbuch der Mineralchemie*, edited by Hofrat Professor Dr. C. Doelter; vol. ii, pt. i, pp. 160; Dresden and Leipzig, Theodor Steinkopff, 1912; price 6·50 marks net), which deals with silica and the silicates, comes fully up to its predecessors in point of view of interest and importance. It opens with a resumé by Professor Becke of the physical characters of the silicates. He compares the refraction of many species with the corresponding value calculated from Gladstone and Dale's well-known law; the agreement is often very close, but discrepancies are met with which call for further investigation. The general theory of the optical characters of isomorphous mixtures is considered, with special reference to the plagioclase felspars. A lucid and thorough account of the paragenesis of the silica minerals comes from the pen of Professor J. Koenigsberger. Professor Doelter himself writes on the vexed question of the constitution of the silicates, and discusses the various theories that have been put forward. He also describes very fully the physical characters of quartz, chalcedony, and opal, the information given being exhaustive and well up-to-date.

XI.—United States Geological Survey.

WE have received Water-supply Papers Nos. 281, 283, and 301, dealing with the Surface Water Supply of the United States, including the North Atlantic Coast and Ohio River Basin; also No. 299, part ii, dealing with stream measurements in San Joaquin River Basin, California. Illustrations are given of the apparatus used in gauging the flow of streams. In No. 299 there are views showing the measurements made by the engineers of the Geological Survey by means of a current meter, which is operated from a bridge, a car suspended on a cable, a boat, and by wading.

The Thirty-third Annual Report of the Director (Mr. George Otis Smith) for the year ended June 30, 1912, contains a useful map showing areas of the United States covered by geologic surveys. There are some interesting remarks on the work of the Committee on Geological Names, their duty being to consider all geologic names of formations suggested by members of the Survey, prior to publication in both official and unofficial works. During the past fiscal year the Committee "considered 143 manuscripts, comprising a total of 21,614 pages and about 5,000 geologic names". Various card-catalogues bearing on nomenclature are kept up for the Committee, whose useful labours might well be followed in other countries.

Bulletin No. 471 (1912) consists of "Contributions to Economic Geology (short papers and preliminary reports), Part II, Mineral Fuels". The subjects dealt with are petroleum and natural gas, coal and lignite; including gas in Alabama, petroleum and gas in Kentucky and Utah, petroleum in California and Wyoming, coal in North Carolina, Colorado, North Mexico, Utah, and Wyoming, lignite and coal in Montana, and lignite in North Dakota. These short papers and reports occupy, with index, etc., 663 pages, and they are accompanied by 62 plates (maps and sections) and 15 text-illustrations. They include topographic and geologic descriptions, records of borings, analyses, etc.

Taking, for example, the report on the "Geology of the San Juan Oil Field, Utah", by Mr. E. G. Woodruff, we learn that the oil-field is situated in the valley of the San Juan River in south-eastern Utah, that the area is part of the Colorado Plateau, consisting of much irregular and uneven ground, of which about 80 per cent is destitute of vegetation, and subject to erosion by the local and occasional, but copious, rains. There are two canyons with precipitous walls, about 1,400 feet deep, and possessing grand scenic beauty. More than 5,000 feet of strata ranging from Carboniferous to Jurassic are exposed in the field, and it is in the older strata, the Goodridge formation of the Pennsylvanian system, that the oil occurs. The oil is generally found in sand or sandstone, but small quantities occur in limestone. The Goodridge Sand, 26 feet thick in places, is one of the most productive beds. Oil springs issue from different strata near the level of the San Juan River, the highest seeps in geological position being those from the Goodridge Sand, the lowest being in stratigraphic distance 1,450 feet below. The deepest well is 1,425 feet, but in some situations oil occurs at about 150 feet from the surface. It is noted that all the prolific wells are situated in synclinal strata, the area being "moderately complicated by north–south folds".

Bulletin No. 501 (1912) is on "The Bonnifield Region, Alaska", by Mr. S. R. Capps. The region contains productive auriferous placers and extensive lignite deposits; there are also possibilities of lode-mining. The report is well illustrated by photographic views and maps.

XII.—Cotteswold Naturalists' Field Club.

PART I of vol. xviii of the Proceedings of this Club (1913) contains the address of the President, the Rev. Walter Butt, who dealt with some problems connected with Prehistoric Man, and concluded that the earliest safe evidence of man's existence in the British Islands was in the Mousterian stage. Reports of various excursions contain much of geological interest, especially in reference to Droitwich, Cleeve Hill, Thornbury and Aust, Painswick and Kimsbury Castle, Bath and Box (the report on which contains a plan of the Box quarries). A more distant excursion was made to Bridport (outside the bounds of the Club), and the report is accompanied by some excellent photographic views of cliff scenery. The original articles include a paper, with one plate, on "Some

Inferior Oolite Brachiopoda", by Messrs. L. Richardson and C. Upton; an account of "A Swallow-hole in the Inferior Oolite near Cheltenham", by Mr. Richardson; notes on "The Distribution of *Calluna* on the Cotteswolds", by Mr. H. H. Knight, who describes the relations of the heather to the soils and substrata; notes by Mr. Upton "On the abundant occurrence of *Involutina liassica* (Jones) in the Lower Lias at Gloucester"—here we miss a reference to the paper on this subject by H. B. Brady (GEOL. MAG., 1864, p. 193); a paper, with one plate, "On the Stratigraphical and Geological Distribution of the Inferior Oolite Echinoids of the West of England (Supplement," by Messrs. Richardson and E. T. Paris; and a description of some "Well-Sinkings on Lansdown, Bath", by the Rev. H. H. Winwood. who refers to the attenuation of the Great Oolite, as indicated by the presence of Forest Marble. Particulars of that formation would be of interest, as it is not shown on the Geological Survey Map. Mr. Roland Austin has compiled a useful Index to the Proceedings of the Club (1846–1912). This replaces Mr. Richardson's Index of 1904.

XIII.—LAVORATIONE RATIONALE DELLE SOLFARE VIRDILIO E MINTINELLA. Monografia Technico-Economica. (A technical and economic Report upon the Sulphur-mines of Virdilio and Mintinella in Sicily: by EMMANUELE CIMONO, Engineer.) 4to; pp. 152, with 2 coloured plates. Palermo: Libreria Internazionale A. Reber, 1912.

ALONGSIDE the road between Naro and Campobello di Licata (Sicily) are the rich sulphur-mines of Virdilio and Mintinella, which form the subject of the elaborate and detailed monograph now before us. The object of this work is to present a rational scheme for the working of the sulphur, and the author hopes that it will be of permanent value, both scientific and economical. In configuration the sulphur-bearing basin has the shape of a wide horseshoe. The first part of this work is devoted to descriptive geological notes, in which the succession of the beds and mode of occurrence of the sulphur are described. The resemblance between the beds of Virdilio and Mintinella and those of other Sicilian localities is also discussed.

Engineering reports connected with the difficulties encountered in working the deposits are contained in the second part, in which also are incorporated the opinions of various authorities on the causes that conduce to vibration and rock-fracture, and suggestions as to precautions that might be taken against catastrophes resulting therefrom. Two schemes for working the mines are considered in detail: one for carrying on operations above ground, and another for underground working. The relative cost of either is discussed, and full calculations as to the amount of overlying material, of transport, excavation, banking, etc., have been included. Statistical tables and full details connected with the exploitation of the sulphur are contained in the last three parts of this monograph, which is illustrated by two good coloured plates of sections and plans.

XIV.—The Resources of Tennessee. By A. H. Purdue and W. A. Nelson. Vol. iii, No. 2, pp. 62–116, April, 1913.

In this number A. H. Purdue contributes two short articles. One outlines the principles of water-supply for cities and towns, and is illustrated by a section showing the water-bearing strata at Etowah. The other points out the grave need for geological investigation of the foundations of large engineering structures.

C. H. Gordon has written an account of the principal types of iron-ore deposits and their origin, with special reference to Tennessee. The deposits of limonite of East Tennessee are shown to be due to the weathering, probably in Tertiary times, of ferruginous limestones of Ordovician age. The hæmatite deposits are of two types: residual deposits, due to the leaching out by surface waters of calcium carbonate in ferruginous limestones; deposits of the Clinton type, in which the hæmatite occurs as beds of original deposition which have since undergone secondary enrichment. This paper contains four figures and numerous analyses.

The discovery of Mastodon remains in a quarry near Nashville is recorded. The remains consisted of teeth and bones, and were found at a depth of 15 feet in a clay-filled solution channel in the Carters Creek Limestone.

XV.—Brief Notices.

1. Institution of Mining and Metallurgy.—We have received the Presidential Address delivered on March 13, by Mr. Bedford McNeill, F.G.S., before this Institution. He discusses the relations between mining and capital, the extension of mining, and makes especial reference to the relative and average annual production of gold and silver at various periods from 1493 to 1911. He also calls attention to the meeting of the International Congress of Mining, Metallurgy, Applied Mechanics, and Practical Geology to be held in London in 1915. The address is accompanied by an admirable portrait of the President.

2. Sinai: Gebel Hammân Farûn.—Mr. G. W. Murray has an interesting note on the structure of this hill in the *Cairo Scientific Journal*, vol. vii, pp. 21–4, February, 1913. The sea-face of Gebel Hammân Farûn shows 45 metres of bedded basalt resting unconformably on variegated shales yielding many fossils, including *Hemiaster*. The basalt is overlain apparently conformably by 15 metres of Oyster limestones, among which *Ostrea vesicularis* is conspicuous. The evidence points to a contemporaneous flow in Santonian times. The hill is faulted down at its north-west end, and the basalts are not seen therefore at the point of previous interest, where the hot springs gush out amongst the beach shingles for some 400 metres.

3. Californian Tertiary Sharks.—Messrs. Jordan and Beal, having received a large collection of shark's teeth from the Kern River, near Oil City, have been enabled to add several species to the fossil sharks of California. When describing these in the Bulletin of the University of California, 1913, they have taken the opportunity

of giving a table of the geological range of Western American sharks from Triassic to Pleistocene.

4. CALIFORNIAN EOCENE MOLLUSCA.—A number of new forms of Eocene Mollusca have been described from the Marysville Buttes by R. E. Dickerson in the Bulletin of the University of California, 1913. The beds were deposited on a coarse-grained andesitic valley floor, overlain by gravels and sands (Ione Beds), which in their turn were capped with andesitic mud-flows, subsequently firmly cemented. The fauna is considered to have accumulated in 100 fathoms under tropical or sub-tropical conditions.

5. FORAMINIFERA OF SOUTHERN CALIFORNIA.—The Bulletin 513 of the Department of the Interior U.S. Geological Survey, 1912, is devoted to a description and illustration of the Pliocene and Pleistocene Foraminifera from Southern California by Rufus M. Bagg. Over a hundred forms are described in ninety-two pages of text, and illustrated in twenty-eight plates by a series of excellent figures. That the author knows his subject is evident from the paucity of 'n.spp.'

6. BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY (PETROLOGY AND MINERALOGY) FOR 1911.—This useful work, compiled for 1911 by John M. Nickles, was published last year as Bulletin 524 of the Department of the Interior U.S. Geological Survey. It contains 1,266 entries, and has a first-class analytical index.

7. PALÆOZOIC SEDIMENTS.—In the *Journal of Geology* (Chicago) for April–May, 1913, is a very suggestive paper by T. C. Brown on the origin of certain Palæozoic sediments. The author discusses the conglomerates, the oolites, and the interbedded sands of the Cambrian and Ordovician rocks of Center County, Pennsylvania. In the same Journal E. S. Bastin has a paper on "Chemical Composition as a criterion in identifying Metamorphosed Sediments", which may be read in conjunction with the preceding.

8. MIOCENE FAUNA OF EGGENBURG.—Dr. F. X. Schaffer deals with this interesting fauna in the Abhandlung der k.k. geologischen Reichsanstalt, vol. xxii, pt. ii (November, 1912). The paper includes the Gasteropoda, Cephalopoda, Crinoids, Echinoids, and Brachiopoda, and is fully illustrated. The fauna is singularly rich in *Cerithium*, *Turritella*, and *Patella*, and the occurrence of several species of *Antedon* is interesting.

REPORTS AND PROCEEDINGS.

I.—THE ROYAL SOCIETY.

June 5, 1913.—Sir Archibald Geikie, K.C.B., President, in the Chair.

The Croonian Lecture was delivered by Dr. Robert Broom, C.M.Z.S., on "The Origin of Mammals".[1]

An endeavour is made to trace the evolution of mammals from Cotylosaurian ancestors through the carnivorous Therapsida. In

[1] The accompanying abstract has been furnished by the author.

Upper Carboniferous times the line probably passed through some primitive generalized Pelycosaurs; in Lower Permian through primitive, probably Therocephalian, Therapsids. In Middle and Upper Permian the line passed through the Gorgonopsia. In Triassic times the mammalian ancestors were small generalized Cynodonts. In Lower Jurassic the mammals are so Cynodont-like, and the Cynodonts so mammal-like, that in no single case are we absolutely certain which is which.

In the Therocephalia, the Gorgonopsia, and the Cynodontia, the skull is very mammal-like. The zygomatic arch is, as in mammals, formed by the jugal and the squamosal. The teeth are divided into incisors, canines, and molars. In the later Gorgonopsians there is an imperfect secondary palate; in Cynodonts a complete secondary palate as in mammals. In Permian Therapsids there is a single occipital condyle; in the Triassic Cynodonts there may be a single condyle slightly divided or two exoccipital condyles. There is, on passing from earlier to later types, a steady increase in the size of the dentary and decrease in the size of the other elements of the jaw. The quadrate also becomes much reduced in the higher types. In Gorgonopsians and probably all earlier types the arch of the atlas is a pair of bones; in Cynodonts, as in mammals, there is a single arch.

It is argued that the small Gorgonopsians fed almost exclusively on the comparatively slow-moving, small, herbivorous Anomodonts. In the Trias the small Anomodonts became very rare, and the carnivorous Therapsids had to feed on other small forms, apparently the more active lizard-like Cotylosaurs, such as *Procolophon*. The change of habit resulted in the Cynodontia.

In Upper Triassic times the larger Cynodonts preyed upon the large Anomodont, *Kannemeyeria*, and carried on their existence so long as these Anomodonts survived, but died out with them about the end of the Trias or in Rhætic times. The small Cynodonts, having neither small Anomodonts nor small Cotylosaurs to feed on, were forced to hunt the very active long-limbed Thecodonts. The greatly increased activity brought about that series of changes which formed the mammals—the flexible skin with hair, the four-chambered heart and warm blood, the loose jaw with teeth for mastication, an increased development of tactile sensation, and a great increase of cerebrum. Not improbably the attacks of the newly evolved Cynodont or mammalian type brought about a corresponding evolution in the Pseudosuchian Thecodonts which ultimately resulted in the formation of Dinosaurs and Birds.

II.—Geological Society of London.

(i) *May* 28, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The President, in referring to the loss which the Society had that day sustained by the decease of John Lubbock, 1st Baron Avebury, recalled the fact that Lord Avebury had been a Fellow of the Society for no less than fifty-eight years, that he had contributed several valuable papers to the Society's Journal, and that he was the recipient of the first Prestwich Medal. The President added that he felt sure that the Fellows would associate themselves with the resolution of condolence and sympathy which the Council had addressed to Lady Avebury.

The following communications were read:—

1. "On the Age of the Suffolk Valleys; with Notes on the Buried Channels of Drift." By Percy G. H. Boswell, B.Sc., F.G.S.

The main watershed of Suffolk follows generally the Chalk escarpment, but keeps rather to the east of it, running in a north-easterly direction from Haverhill in the extreme south-west of the county. Suffolk forms a plateau, 100 to 400 feet O.D., dissected by a valley-system which is palmate in form, the chief rivers, taken from north to south, being the Waveney, the Alde, the Deben, the Gipping (with its estuary, the Orwell), the Brett, and the Stour. The Little Ouse and the Lark flow north-westwards into the Wash basin.

The strata (Chalk, Lower London Tertiaries, London Clay, Crags, etc.) cut through by the valleys, and the mantle of glacial deposits (sands, gravels, and loams, Upper Boulder-clay, and morainic gravels), which more or less covers the whole county, are described briefly. Reasons are given for thinking that the Contorted Drift does not extend far south of the Waveney. The valleys, although they may have been etched earlier, are on direct evidence post-Pliocene in age; but, by analogy with the Waveney and the Norfolk rivers, they may be younger than the Contorted Drift.

The Upper Boulder-clay (= the Great Chalky Boulder-clay of S. V. Wood, jun.) covers much of the plateau, and wraps down into the valleys in a very characteristic manner. The glacial Sands, etc., below it also appear at times to lie on the valley-slopes. Intense glacial disturbances are found to be situated always on 'bluffs' or 'spurs' of the plateau projecting into the wide open valleys, which were thus in existence before the advent of the valley glaciers to the action of which the disturbances have been attributed.

In each of the main valleys occur one or more buried channels of Drift; borings made recently allow these to be described in detail, and the deposits filling them to be discussed. A contour map of the top of the Chalk is prepared for the county, and this serves to bring out the anomalies in the valleys. These buried channels were probably eroded by sub-glacial water-streams, and a comparison is instituted between them and the Föhrden of North Germany, Schleswig-Holstein, Kerguelen, etc., described in detail by Dr. Werth and others.

The evidence, therefore, indicates that the pre-Glacial or early Glacial contours of Suffolk were in the main much as they are now. The form of the rivers and valleys suggests that some amount of capture may have taken place before the deposition of the Upper Boulder-clay; and that the present river-system is recovering from a state of arrested development, due to the 'overloading' of the valleys with Drift deposits and torrential debris during the last glaciation of the area, and to the subsidence (some 60 to 80 feet) which followed it.

2. "The Internal Structure of Upper Silurian Rugose Corals from the Grindrod Collection, Oxford Museum." By Donald Esme Innes, B.A. (Communicated by Professor W. J. Sollas, Sc.D., F.R.S., F.G.S.)

In this paper the following genera and species are described:—

> *Palæocyclus porpita*, *P. fletcheri*, *P. rugosus*.
> *Cystiphyllum siluriense*, *C. cylindricum*.
> *Cyathophyllum* (?): a new species.
> *Cyathophyllum articulatum*, *C. truncatum*.
> *Strombodes murchisoni*, *Str. typus*, *Str. diffluens*.

The new species of *Cyathophyllum* (?) is of especial interest. It was figured by Milne Edwards & Haime as *Cystiphyllum cylindricum*, Lonsdale, with which it has no close affinities. It combines characters of the Silurian *Cyathophylla* and *Halliæ* with those of the Lower Carboniferous *Caniniæ*.

Particular attention is paid to the construction of a septum in the various genera, the following types being well represented:—

(1) Radial spines on the vesicles, with their bases often connected by a web. Example: *Cystiphyllum*.
(2) Rods placed in juxtaposition and cemented together. Example: *Palæocyclus*.
(3) Simple plates. Example: *Cyathophyllum articulatum*.
(4) Crumpled plates. Example: *Cyathophyllum* (?), the new species.
(5) Plates with backward costal prolongations. Example: *Strombodes*.

Comparison of the Upper Silurian coral facies with that of the Lower Carboniferous shows that *Cystiphyllum*, in its vesicular and spinose structure, bears a close resemblance to the compound *Michelinia*, while *Strombodes* is allied in structure to *Cyathophyllum regium* of the Viséan.

(ii) *June* 11, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "Certain Upper Jurassic Strata of England." By Dr. Hans Salfeld, University of Göttingen. (Communicated by S. S. Buckman, F.G.S.)

The writer has studied the Upper Jurassic strata of North-Western Germany, the Boulonnais, and Southern England with special reference to the Ammonites and their zones. The results of his labours are to be published in detail; but, in anticipation, he offers to the Society an epitome of his conclusions with regard to the English strata.

The localities with which he deals are the Dorset coast from Kimmeridge to Abbotsbury, and the Wiltshire exposures at Swindon and Westbury, with an incidental reference to Market Rasen. The formations concerned are the Portlandian, Kimmeridgian, and for a starting-point the Upper Oxfordian: these terms being employed in the German sense. The Upper Oxfordian = upper part of the English Corallian (+ Kimmeridge Clay locally) is divided into three zones, found at Osmington, Westbury, and Swindon. The Kimmeridgian is divided into five zones, and is equal mainly to the Lower Kimmeridge Clay of English authors, with one important exception;

the Abbotsbury Iron-ore is placed as the second zone of the Kimmeridgian, and is correlated with the Market-Rasen Clays. The Portlandian is divided into nine zones; but the term as used in the paper includes the Portland Oolites, Portland Sands, and Upper Kimmeridge Clay of English authors.

Three new genera of Ammonites are named, and two new zonal species of Ammonites are defined.

2. "The Volcanic Rocks of the Forfarshire Coast and their Associated Sediments." By Albert Jowett, M.Sc., F.G.S.

The peculiar intermingling of fine sediments with the Lower Old Red Sandstone lavas of Scotland is well known from the writings of Sir Archibald Geikie.

The author has found that in Forfarshire these sediments are frequently amygdaloidal, the production of the cavities having been accompanied by the buckling and fracturing of the layers of sediment. It is suggested that such effects may result from the pouring of molten rock over wet unconsolidated sediment: steam being produced within the sediment, but unable to escape owing to the presence of the overlying rock. The surface of the sediment was apparently ploughed up by the lava, the lower portion of which occasionally contains rounded nodules of hard amygdaloidal sediment. The sediment is sometimes slightly altered where in contact with the volcanic rock.

Further evidence of the pouring of molten rock into water is furnished by the occurrence of a rude pillow-structure in some of the lavas.

Several lenticular conglomerates are interbedded with the volcanic rocks, resting upon eroded surfaces of the latter. The conglomerates consist of large rounded blocks of volcanic rock, enclosed in a matrix composed almost entirely of volcanic debris.

Most of the volcanic rocks are olivine-basalts, rhombic pyroxene as well as olivine sometimes being present. Some contain rhombic pyroxene to the exclusion of olivine. A few porphyrite dykes of Lower Old Red Sandstone age are intruded in the lavas.

The fine sediments consist of a variable proportion of quartz and mica and a little felspar, together with chlorite, iron oxides, and occasional minute fragments of volcanic rock.

Calcite, quartz, chalcedony, and chlorite are the commonest minerals in the amygdules, in both lavas and sediments.

In the south-west of Lunan Bay, a mass of Upper Old Red Sandstone with a basal conglomerate has been found resting unconformably upon the Lower Old Red Sandstone volcanic rocks.

3. "On a group of Metamorphosed Sediments situate between Machakos and Lake Magadi in British East Africa." By John Parkinson, M.A., F.G.S.

That part of British East Africa which borders the Athi Plains and extends westwards to the eastern edge of the Rift Valley, is undulating country composed of foliated rocks of ancient appearance, crossed by pegmatites which are unconnected with any apparent granitic intrusions.

A series of crystalline rocks, for which it is proposed to use the name Turoka Series, is situated just below the great lava plateau of the Kapiti Plains, and forms the ground drained by the head-waters of the Turoka River. The following rock-types are present in the chief section, in the following apparent upward succession :—

(1) Hornblende-schist, seen to a thickness of 3 ft. 5 in.; (2) flaggy and impure marble, 3 feet; (3) biotite-gneiss, 2 feet; (4) calc-mica rock with lenticles of biotite-gneiss, 3 ft. 8 in.; (5) hornblende-schist similar to No. 1, 1 foot; (6) impure calc-rock, 2 feet; (7) quartz-felspar vein, 2 feet; (8) hornblende-schist, 2 feet; and (9) impure calc-rock, resembling No. 5 and about 4 feet thick.

A detailed petrographical description is given of the various rock-types present in the series, which, in addition to those mentioned above, includes kyanite-garnet-gneisses and a scapolite-garnet rock.

The author concludes that the group represents a series of metamorphosed arenaceous and calcareous sediments, and that there is a complete passage from calc-mica rocks into biotite-gneisses.

Mineralogical Society.

June 17.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

W. L. Bragg: Crystal Structure as revealed by Röntgen Radiation. An analysis of the diffraction patterns obtained when X-rays traverse a section of a crystal shows that in many simple crystals the diffraction is caused by a set of points arranged on a space-lattice. This is the case when the molecule contains either a single heavy atom of at least twice the atomic weight of the other constituents, or only two atoms of nearly the same atomic weight. By comparison of the pattern given by certain alkaline halides, such as K C I and K Br, a definite structure of these cubic crystals is clearly indicated, and it would appear that the atoms are arranged on a space-lattice whose elementary parallelopiped is a cube, alternate atoms being along the axes, so that atoms of one kind form a face-centred cubic space-lattice. These conclusions are confirmed by a comparison of the distances between planes parallel to the various faces of these crystals carried out by means of the X-ray reflection-spectrometer, and it appears that a single atom is associated with each point of the space-lattice which diffracts in the case, for instance, of the alkaline halides, calcite, fluor, blende, and pyrites. If the suggested structure of the crystals is correct, a simple calculation gives the absolute wave-length in centimetres of the homogeneous components in the X-ray beam from a platinum anticathode.—H. V. Ellesworth: The Crystal Habit of Topaz from New Brunswick, Canada. Topaz, a rare mineral in Canada, occurs in York Co., New Brunswick, associated with wolframite, molybdenite, and a little fluor. On the crystals the forms 110, 120, 011, 112 are prominent, but other pyramid and prism forms are sometimes present, sixteen forms altogether being observed. Dull faces were coated with silver by Brashear's process, in which an ammoniacal solution of silver nitrate is reduced by a sugar solution.—Dr. G. T. Prior: On the Meteoric Stone which fell at Baroti, Punjab, India, in September, 1911. The stone, which belongs to the 'intermediate chondrite' group of Tschermak's classification, was found on analysis to contain about 9 per cent of nickel-iron and 7 per cent of troilite, which were disseminated in small particles through a colourless matrix of enstatite and olivine showing only few chondrules.—Dr. A. W. Gibb exhibited kämmererite from Unst, Shetland Islands.

IV.—Zoological Society of London.

May 20, 1913.—Professor E. A. Minchin, M.A., F.R.S., Vice-President, in the Chair.

Dr. R. Broom, C.M.Z.S., read a paper "On the South African Pseudosuchian Reptile *Euparkeria* and allied Genera". Besides giving an account of the very completely known South African form, he also discussed the structure of the Elgin allied forms, *Ornithosuchus* and others. The group of Pseudosuchians he regarded as an extremely important primitive reptilian order, as there is good reason to believe that not only does it contain the ancestor of the Dinosaurs, but also the ancestors of the Pterodactyles and Birds. *Euparkeria* and *Ornithosuchus* are, in structure, almost Dinosaurs, and it is held that when the bipedal habit was more fully acquired the few characters not quite Dinosaurian would become Dinosaurian. Birds are held to have originated from a Pseudosuchian which, by a bipedal habit, had acquired a Dinosaur-like hind limb, and had then become arboreal in habit and acquired the peculiar power of flight.

June 3, 1913.—Professor E. W. MacBride, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

A paper on "Some Miocene Cirripedes of the genera *Hexelasma* and *Scalpellum* from New Zealand", communicated by Dr. W. T. Calman, F.Z.S., was read by Mr. T. H. Withers, F.G.S. An account is therein given of the 'gigantic Cirripede' of New Zealand, originally described as *Scalpellum aucklandicum*, of which remains have long been known to occur in the Waitemata Beds (Miocene) of Motutapu Island, Auckland Harbour. The valves of this Cirripede attain a length of 8 inches, and have been previously supposed to belong to a pedunculate form, but while Sir James Hector (1887) referred them to the genus *Scalpellum*, Professor W. Blaxland Benham[1] (1903) thought that they approached more closely to the genus *Pollicipes*. From a study of the original material collected by Professor James Park (1887), it is now shown that this Cirripede is a sessile form allied to *Balanus*, and it is referred to Dr. P. P. C. Hoek's recently instituted genus *Hexelasma* (1903). A smaller undetermined species of *Hexelasma* and a new species of *Scalpellum* (*sensu lato*) are also described. These are in the collection of the Geological Survey, New Zealand, and occur in the same beds as the 'gigantic Cirripede'.

A second new species of *Scalpellum* is founded on some valves from New Zealand, and a restoration is given, the remains being sufficient to justify their reference to the sub-genus *Arcoscalpellum*, Hoek.

[1] Geol. Mag., 1903, p. 110, Pls. IX, X.

OBITUARY.

THOMAS FRANCIS JAMIESON, LL.D., F.G.S.

BORN APRIL 26, 1829. DIED MAY 24, 1913.

WE regret to record the death of T. F. Jamieson, of Ellon, Aberdeenshire, distinguished for his researches on the glacial geology of Scotland. The results of his earliest geological work and of all his more important subsequent observations were communicated to the Geological Society of London, introduced in the first instance by Murchison in 1858. Four years later Jamieson was elected a Fellow of the Society, and in 1898 he was awarded the Murchison Medal by the Council. On that occasion, although unable to be present, he wrote expressing his gratification and his "recollection of the warm-hearted Sir Roderick", from whom he had received much kind attention and help many years ago when a young man.

Jamieson was born at Aberdeen, and educated at Marischal College during the years 1843–6, but he did not graduate. His energies were now devoted to rural economy. For many years he was Factor on the Ellon estate, and subsequently took the farm of Mains of Waterton, and became widely known and respected as an expert in agricultural matters. In 1862 he was appointed Fordyce Lecturer on Agricultural Research in the University of Aberdeen, his services being recognized in 1884 by the conferment of the honorary degree of LL.D.[1] Meanwhile his leisure time was occupied with studies of the various Drift deposits and the effects of glacial action. In his first paper, on the "Pleistocene Deposits of Aberdeenshire" (read in 1858), he described various mounds and ridges of gravel and the shells from the drifts, which in his opinion were accumulated at a time when the land was 450 feet lower. Subsequently it stood higher than it does now.

In another paper (1860) on the "Drift and Rolled Gravel of the North of Scotland", he dealt more fully with the Pleistocene phenomena, and for the first time brought forward detailed evidence relating to the land-glaciation of Scotland, to the fluting, grooving, and scratching of the rocks, the dispersion of boulders, etc. Interesting observations were also recorded on the positions assumed by pebbles in streams.

In the same year he drew attention to the occurrence of characteristic Crag shells in the Drift of Aberdeenshire, and regarded the evidence as indicating a patch of Crag preserved in situ. In 1882, in a further account, he gave reasons for believing that the shells were derived.

In 1862, in a paper on the "Ice-worn Rocks of Scotland", he pointed out the great erosion by ice-action, and the presence of boulders far above their parent rocks. He illustrated his remarks on land-ice by reference to phenomena in Greenland and on the Antarctic continent, and gave a sketch-map of Scotland showing the direction of the glacial markings.

[1] For these particulars we are indebted to the *Aberdeen Free Press*, May 26, 1913.

In 1863 his great paper on the "Parallel Roads of Glen Roy" was published, and therein he showed that they are beaches of freshwater lakes, which originated from glaciers damming the mouths of valleys and reversing their drainage. The date of the lakes he regarded as posterior to the great land-glaciation of Scotland.

As remarked by Lyell (*Antiquity of Man*, 4th ed., p. 305), Mr. Jamieson "observed many facts highly confirmatory of the theory of glacier-lakes", which had been previously suggested by Agassiz and Buckland, and "showed that this theory affords a complete explanation of all the most striking peculiarities".[1]

In 1891 he published "Supplementary Remarks on Glen Roy", dealing with subsequent explanations and further supporting his original views.

In 1865 he read an important paper on the "History of the Last Geological Changes in Scotland". In this he referred to evidence of the Mammoth having inhabited Scotland before the Glacial period. He noted the enormous thickness of the land-ice, Schiehallion (3,500 feet high) being glaciated near to the top as well as on its flanks. He considered that the ice was developed as a thick cake and flowed off "not so much on account of the inclination of the bed on which it rested", but "in the way that a heap of grain flows off when poured down on the floor of a granary . . . given a floor of infinite extension, and a pile of grain of sufficient amount, the mass would move outward to any distance". He concluded that "the want of much inclination in the surface of a country, and the absence of great Alpine heights, are therefore objections of no moment to the movement of land-ice, *provided we have snow enough*".

He further noted how the Boulder-clay varies in colour and character according to the rocks from which it was derived, and he expressed his opinion that certain kaims (or kames) may have been formed by the ridging-up of gravel in front of a glacier.

Finally, he discussed the introduction of the plants and animals into the British Isles since the Glacial period, admitting that "ice might have formed a bridge to some, but not to the greater part". This paper contains a long list of Glacial shells.

In 1866 he described the "Glacial Phenomena of Caithness", and in 1874 he dealt with the "Last Stage of the Glacial Period in North Britain", discussing the formation of kaims and eskers, and advocating the development of a second ice-sheet, but not so thick nor so extensive as that in the earlier glaciation. In 1882 he read a paper on the "Red Clay of Aberdeenshire", considering that it was laid down before the last advance of the glaciers.

We need only further mention that Mr. Jamieson on two occasions entered other geological fields, writing in 1861 on the "Structure of the South-West Highlands of Scotland (parts of Bute, Cowal, and Jura)", and in 1871 on the "Older Metamorphic Rocks and Granite of Banffshire", when he advocated the metamorphic origin of the granite, and was supported by Ramsay.[2] H. B. W.

[1] See also E. B. Bailey, Proc. Geol. Assoc., xxii, 203, 1911.

[2] Seventeen papers, from 1865 to 1908, are credited to Mr. T. F. Jamieson in the GEOLOGICAL MAGAZINE.—ED.

THE RIGHT HON. BARON AVEBURY,
D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Etc.

Born April 30, 1834. Died May 28, 1913.

In the death of Lord Avebury natural science has lost one of its most enthusiastic and cultured disciples. Born at Eaton Place, London, he was the son of Sir John William Lubbock, 3rd Baronet, F.R.S., F.G.S., a distinguished mathematician and astronomer, who died in 1865. John Lubbock succeeded to the baronetcy in that year, and was created Baron Avebury in 1900. He received a school education at Eton, but no University training, as his services were wanted before he had attained the age of 15 in the banking-house of Robarts, Lubbock & Co., Lombard Street, an establishment of which his father was then the Head. John Lubbock became a partner in the firm in 1856 and succeeded to the chief position on the death of his father. It will be unnecessary here to refer in particular to his great business capacity and to the services he rendered to commerce, the arts, and to education in general. As a Member of Parliament he represented Maidstone and afterwards the University of London, taking an active part in promoting the Ancient Monuments Act, the Open Spaces Act, and many other measures.

Interest in the study of natural history was developed in Lubbock at an early age, and the proximity of his home at High Elms, near Farnborough, to that of Darwin at Down, in Kent, no doubt greatly influenced the character of his recreative pursuits. In course of time he acquired a wide range of knowledge in archæology, entomology, botany, and geology, and we may be content here to refer to his researches on the first and last of these subjects.

One of his earliest discoveries, made in 1855 in company with Charles Kingsley, was that of the skull of a musk-ox in a gravel-pit close to Maidenhead railway station, and the specimen was described by Owen in the following year as the first example which had come under his notice from a British locality. In 1860 and again in 1862 and 1863 he joined Prestwich and others in excursions to the flint-implement-bearing districts of Amiens and Abbeville, and in 1861 he spent a holiday in Switzerland with Tyndall and Huxley. The knowledge thereby obtained stimulated those further studies which led in one direction to the publication in 1865 of Lubbock's *Prehistoric Times, as illustrated by Ancient Remains and the Manners and Customs of Modern Savages*. This work was followed in 1870 by *The Origin of Civilisation and the Primitive Condition of Man*. Both works have attained to the sixth edition. It may further be mentioned that he was associated with Huxley, Busk, and others as one of the editors of the *Natural History Review* (1861–5). In 1867 he brought before the Geological Society a paper "On the Parallel Roads of Glen Roy", advocating their formation in a lake, the waves in which did not arrest but threw down to lower levels the angular debris of the hill-slopes. His interest in Switzerland led to many journeys to that country and to the publication in 1896 of *The Scenery of Switzerland and the Causes to which it is due*. Of this work a fourth edition has been issued. A companion volume on

The Scenery of England and the Causes to which it is due was published in 1902, and the subject, beautifully illustrated, clearly expounded, and treated in an enthusiastic spirit, made the work so popular that it has reached a fifth edition.

In 1903 Lord Avebury gave to the Geological Society the results of "An Experiment in Mountain-building", based on apparatus which produced compression in two directions. The features thus produced on pieces of carpet-baize and alternating layers of sand were illustrated in his short published account of the phenomena.

He was elected a Fellow of the Geological Society in 1855, and in 1903 the Council awarded to him the first Prestwich Medal. He was elected a Fellow of the Royal Society in 1858, and became a Trustee of the British Museum in 1878, taking a warm interest in its affairs, and especially in the Natural History branch, afterwards established in South Kensington. He was chosen president of many societies representing diverse scientific and practical subjects, among them the Linnean, Royal Microscopical, Ray, Entomological, and Statistical Societies, and the Anthropological Institute. As the representative of many sciences he was fitly selected to preside over the jubilee meeting of the British Association held at York in 1881.

Lord Avebury was twice married, his second wife being daughter of General Pitt-Rivers, F.R.S. He died at his seaside residence, Kingsgate Castle, near Margate, and was buried on May 31 at Farnborough churchyard, Kent. He is succeeded in the Peerage by the Hon. John Birkbeck Lubbock, his eldest son.

HERBERT KELSALL SLATER, F.G.S.

BORN AUGUST 28, 1875. DIED MAY 2, 1913.

We regret to record the death from snake-bite of Mr. Herbert Kelsall Slater, F.G.S., Assistant Geologist and Acting Second State Geologist to the Mysore Government. He was the son of the Rev. T. E. Slater, a well-known missionary in Mysore, and was educated at Bishop's Stortford College, Herts, and the Central College, Bangalore. In October, 1894, he joined the newly formed Mysore Geological Department under Mr. Bruce Foote, and afterwards served under his successors, Dr. J. W. Evans and Dr. W. F. Smeeth. He had already acquired a competent knowledge of geology in India when he returned to England in 1901 and studied at the Royal College of Science under Professor J. W. Judd. In 1909 he again visited this country for purposes of study, and afterwards spent some months in Canada and made himself familiar with its crystalline rocks, as these present many points of similarity to those on which he was working in India. He mapped a considerable portion of Mysore, especially in the Shimoga, Tarikere, and Kadur Districts, which lie in the north and west of the State, and brought an independent mind to the problems that presented themselves. His work will be found in the Records of the Mysore Geological Department. See vol. ii, pp. 118–30, 1899; vol. iii, pp. 148–62, 1901; vol. iv, pp. 119–46, 1903; vol. v, pt. ii, pp. 35–56, 1904; vol. vi, pt. ii, pp. 5–26, 1905 ('intrusive' and 'corrosive' quartz); vol. vii, pt. ii, pp. 1–20, 1906 (describing a remarkable conglomerate in the schists between Birur and Tarikere); vol. viii, pp. 31–72, 1907 (iron-bearing rocks associated with charnockite); vol. ix, pp. 35–72, 1908 (banded magnetite quartzites). He also reported to the Government on various metalliferous deposits and building stones.

On the morning of his death, Mr. Slater was at a short distance from his camp near Tirthahalli, in the Shimoga District, when he trod upon a large snake, which coiled itself round his boot and bit him repeatedly under the knee through stout cord breeches. Death took place some twelve hours later. Mr. Slater leaves a widow and three young children. J. W. E.

LESTER FRANK WARD, A.M., LL.D.

We learn from *Nature* that Dr. Lester Frank Ward, A.M., LL.D., Professor of Sociology at Brown University, Providence, R.I., and formerly Palæontologist of the U.S. Geological Survey, died in Washington on April 18, in his 72nd year. He was born in 1841 at Joliet, Illinois, and was known to geologists more especially by his researches on the Flora of the Laramie Group, which he regarded as having equally Upper Cretaceous and Lower Tertiary affinities.

ERNST ANTON LEOPOLD KITTL.

BORN DECEMBER 2, 1854. DIED MAY 1, 1913.

The death is announced of Professor Ernst Kittl, who was for many years associated with the geological and palæontological department of the Imperial Court Natural History Museum of Vienna, first as assistant and ultimately as director. In 1885 he published two papers on the Lower Pliocene Mammalia of Maragha, Persia, and during subsequent years he prepared numerous other important papers on fossils, chiefly Mollusca. He also wrote a Guide Book to the Geology of the Salzkammergut, for the use of the International Geological Congress which met in Vienna in 1903.

WILLIAM FOX, M. INST. C. E.

We regret to record the death on June 14, aged 66, of William Fox, M. Inst. C. E., M. Inst. Mech. E., an eminent waterworks engineer, whose labours naturally brought him into association with various geological problems. For many years he was a Fellow of the Geological Society, but had recently resigned.

MISCELLANEOUS.

Mr. Charles Panzetta Chatwin, of the Geological Department of the British Museum (Natural History), has been appointed Assistant Librarian to the Geological Society of London. Mr. Chatwin carries with him the cordial wishes of his friends, who feel that his many qualifications will in time allow him to settle down into a long career of usefulness to the Fellows of the Society.

Portion of a trunk of *Lepidodendron veltheimianum*, Sternb., from French, Lick, Indiana. ⅓ nat. size.

THE
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No. VIII.—AUGUST, 1913.

ORIGINAL ARTICLES.

I.—Note on a Process of Fossilization in the Palæozoic Lycopods.[1]

By E. M. Kindle, Department of Mines, Geological Survey of Canada, Ottawa, Ontario.

(PLATE XI.)

MOST collections of fossil plants include specimens of tree-trunks or branches in which the bark is preserved in great perfection, while no trace of the structure of the trunk within the bark remains. Striking examples of this type of fossilization, in which the bark is preserved in exquisite detail while the space within the bark is wholly filled with fine siliceous sediments showing no trace of the original plant structure, occur frequently among the various species of *Sigillaria* and *Lepidodendron*. The fossilized armour-like outer cortex of *Lepidodendron* fails to retain any remnant of the inner woody material about as often as the various molluscan species of *Spirifer* fail to preserve their delicate internal spires. We know from the silicified specimens which have been found that the greater part of the trunk in *Lepidodendron* is occupied by a soft middle cortex which is very readily disposed of by micro-organisms. The relatively small cylinder of secondary wood which is found in most species which have attained to a large growth was itself rather susceptible to decay, the tracheids being relatively thin-walled, with the medullary cells very large and the rays voluminous.[2] Innumerable examples of the entire failure of the woody tissue of these Lycopods to survive the processes which left the outer cortex admirably preserved occur in the fine-grained sandstones of Pottsville age in Orange County, Indiana. These beds, which have long been quarried for the manufacture of whetstones, contain numerous fossil trunks of *Lepidodendron veltheimianum*, Sternb. (Plate XI), which show the carbonized bark in a good state of preservation, while the space inside the bark is wholly filled with very fine sand similar to that of the strata in which the fossils lie. These sand-filled tree-trunks generally retain approximately their original outline, except for a slight flattening of the trunk. Two trunks of *Lepidodendron* about 10 inches in diameter and 8 feet in height were observed at the time of my visit standing upright in one of the whetstone quarries. The largest trunk seen had a circumference of 4 ft. 8 in. The usual size of the trunk is 6 to 15 inches in

[1] Published with the permission of the Director of the Geological Survey of Canada.

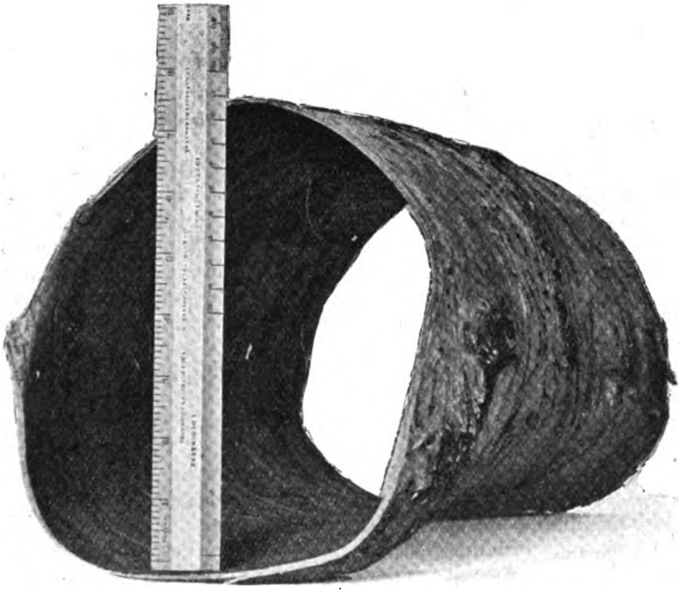
[2] Letter to the author from David White.

diameter. None of the trunks observed in the whetstone quarries, whether large or small, showed any trace of woody tissue within the bark, which was usually altered to coal. Similar sand-filled trunks of *Lepidodendron* and *Sigillaria* have been described by Dawson from Joggins, Nova Scotia, and by various geologists from other localities. The exact conditions under which the substitution of sand for woody tissue within the bark occurred during the fossilization of the latter have, so far as the writer is aware, never been illustrated by examples from our present forests. Rational explanations of the obscure phenomena of the past are often facilitated by means of the analogy supplied by existing agencies. I may therefore venture to call attention to the remarkable resistance to decay of the bark of the common canoe-birch and the equally striking susceptibility to decay of the wood of this tree. Consideration of the differential rate of decay of the bark and the wood of the birch throws much light on the process which has so often produced the kind of fossilization represented by the sand-filled bark of the *Lepidodendron*.

The decay of wood is essentially a biological process resulting directly from the metabolism of the fungi and bacteria which gain access to it. But since moisture and free oxygen are essential to the life of these organisms, wood kept either in a very dry atmosphere or under water is practically immune from decay. The protective agency of water is illustrated by the fact that many of the oak piles in a certain town in Wales which were used in the construction of a dock five hundred years ago are still doing service. It seems clear that the degree of resistance of various kinds of woods to decay depends primarily not upon the texture of the woody tissue but upon the presence or absence of substances in it which fail to support or are directly harmful to the life of destructive fungi. Thus pitch and resin in the soft wood of the conifers and tannin in the cells of the oak are unfavourable to the growth of fungi. During life the bark of all trees is highly resistant to colonization by either fungi or bacteria, and until broken affords complete immunity from their attacks on the enclosed wood. After the death of the tree, however, the bark in many species loses the qualities which made it while the vital processes were active immune to the vital activities of fungi and micro-organisms, and decay may proceed in it much more rapidly than in the wood. This is true in the case of the walnut, beech, tulip, and many other trees where the bark completely decays or breaks up into small fragments while the wood is still in a good state of preservation. In the case of the birch, however, the immunity to decay which characterizes the bark of all living trees persists to a remarkable degree after death. So great is this resistance in the canoe-birch, *Betula papyracea*, that the wood may completely disappear while the bark is still in a perfect state of preservation and retains the original shape of the tree-trunk.

The photograph (Text-figure) shows a section of the bark of a birch-tree from Manitoba in which the wood had almost completely decayed and disappeared. This bark shell which retained but a trace of decomposed woody dust, however, is wholly untouched by decay, and similar examples may be observed wherever birches flourish.

Another section of a small birch-tree represented by perfectly preserved bark from which the wood had wholly disappeared illustrates well the possibilities which the birch affords for the formation of sand-filled fossil tree-trunks similar in their general features to those of the Palæozoic Lycopods. This was found nearly filled with sand and partially buried in a river bar. The density of the bark of the birch is such that a section of it remains almost completely submerged when in the water. This characteristic would facilitate its speedy sinking and burial in sediment whenever subjected to fluvial action. The birch-bark specimen shown in the figure has suffered a slight flattening, resulting from the decay and removal of the supporting wood. It should be noted that this slight flattening of the birch-bark is duplicated very often in the fossilized trunks of *Lepidodendron*. The



Section of the bark of the trunk of the canoe-birch from which the wood has completely decayed, but leaving the bark in a nearly perfect state of preservation.

partially sand-filled section of birch-bark just alluded to clearly illustrates how perfectly one of the trees of our present flora combines in itself characteristics which would lead to the same kind of fossilization so often met with in *Lepidodendron*. Observations of the empty bark shells of decayed birch-trees in the Canadian forests can hardly fail to convince one that *Lepidodendron* possessed a bark which, like that of the birch, far outlasted the woody interior. It appears most probable that the bark cylinders of the fossil Carboniferous Lycopods were generally hollowed out by rapid decay of the wood and then filled with sediment before fossilization began, just as empty birch-bark tree-trunks are now being prepared for fossilization in Canadian lakes and rivers.[1]

[*Note.*—Excellent sound timber for gate-posts and other agricultural purposes is obtained both in Scotland and Ireland from the perfectly preserved bog-oak and other trees found in the peat. The piles of the Swiss lake-dwellings (of Stone and Bronze age) testify by their soundness the durability of wood under water, the only important change being their *blackened* condition.—Ed.]

EXPLANATION OF PLATE XI.

Portion of a trunk of *Lepidodendron veltheimianum*, Sternb., from French, Lick, Ind. ⅛ nat. size.

The specimen represents a mould composed of fine siliceous sediments which have been deposited inside a section of empty bark trunk. A portion of the original carbonized bark which still adheres to the mould is seen in the dark irregular patches.

II.—*Micropholis Stowi*, Huxley, a Temnospondylous Amphibian from South Africa.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in University College, London.

Micropholis Stowi was described by Huxley in 1859 from a small and very incompletely preserved skull found by G. W. Stow at Rhenosterberg (north-west of New Bethesda), District Graaf Reinet, Cape Colony. Subsequently R. Owen described another specimen as *Petrophryne granulata*. In his description he suggested that it might prove to be identical with Huxley's type. The British Museum now contains these two type-specimens and three other examples of the form, all except Huxley's type being from the *Procolophon* zone of Donnybrook, Upper Zwartkei, District Queenstown.

Owen's excellent description and beautiful figures have already made clear the general structure of the roof of the skull, but it is now possible to make out some more sutures, all of which are represented in Fig. 1. The most remarkable features are—

1. The small bone between the premaxillæ. This is a small bone with the same ornament of tubercles as the other skull bones, lying rather loosely in a small fenestra left between the internasal processes of the premaxillæ. The fenestra is present in the three specimens which show this region, and in one small skull it is not filled with a bone. I can find no exact parallel for this bone, but in two types, *Sclerocephalus Roemeri* (H. v. Meyer) and a small Stegocephalian,

[1] Dr. G. R. Wieland, who kindly read the MS. of this paper, has furnished the following interesting memorandum: Indeed, it is curiously in accord with the foregoing facts that in the Palæozoic the thin rind of bark not only tended to outlast the wood in various types, but in turn sometimes aided in the conservation of lesser stems subsequently floated into the bark cavity. In the Laggan Bay bark cylinder figured by Seward no less than five of these floated-in *Lepidodendron* stems appear in fair conservation, while the fact that the cuticular layer must have been remarkably resistant is fully attested by the well-known occurrence in the Permian of Tonea of the thin bands of "paper coal", made up as shown by Weiller of the little-changed and readily stained cuticles of *Bothrodendron*.

(cf. *Ricnodon*), (B.M.N.H. R. 2818) from the Permian Gas Coal of Nyran, Bohemia, there is a small median element in the roof of the skull between the nasals and frontals. I propose to call the anterior of these bones, that which occurs in *Micropholis*, the internasal and the other the interfrontal. Their occurrence is interesting in connection with the median bones so commonly found in the skulls of Dipnoans, which are remotely allied to the Tetrapods.

2. There is a distinct septomaxillare shown on each side in two specimens. It is a little curved plate of bone lying inside the nostril and articulating by its outer edge with the lachrymal. This bone has only once been recorded before in a Stegocephalian, in *Eryops* by Case; it also occurs in '*Bothriceps*' *Huxleyi*.

3. The arrangement of the bones round the orbit is extremely unusual. The lachrymal is a large bone entering into the borders of the orbit and nostril; this condition, which obtains in many primitive reptiles, is very rare in Stegocephalia. Four of the skulls show very

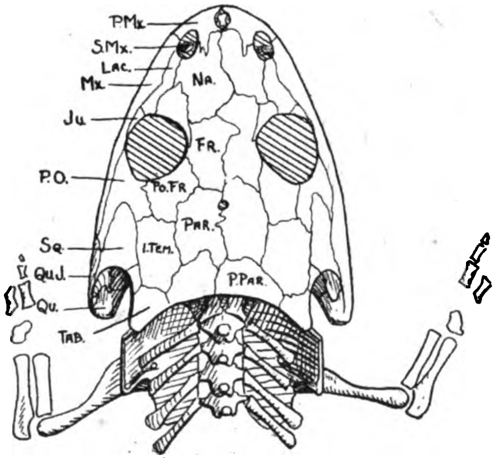


Fig. 1. *Micropholis Stowi*, Hux. Dorsal surface of anterior part of skeleton. × 1. Skull with all sutures on upper surface from R. 510. Vertebræ, ribs, shoulder-girdle, humeri from R. 510*a*. Forearm and hand and quadrate from specimens in the Geological Society's Collection. *Fr.* frontal; *I.Tem.* intertemporal; *Ju.* jugal; *Lac.* lachrymal; *Mx.* maxilla; *Na.* nasal; *P.Mx.* premaxilla; *P.O.* post-orbital; *P.Par.* post-parietal; *Par.* parietal; *Po.Fr.* post-frontal; *Qu.* quadrate; *Qu.J.* quadrato-jugal; *S.Mx.* septomaxilla; *Sq.* squamosal; *Tab.* tabular.

clearly the course of the ductus naso-lachrymalis (Text-fig. 2), which is a narrow canal running in the substance of the lachrymal bone from the orbit, which it leaves by two openings, to the nostril, where it opens below and behind the septomaxilla. This is, I believe, the first recognition of a ductus naso-lachrymalis in the Stegocephalia, and the occurrence is very interesting from several points of view—

(*a*) The very superficial position of the duct. In development in recent types this begins merely as an epidermal thickening which grows down into the head and subsequently acquires a lumen; in

Micropholis we have an early condition where the duct is still in the skin and has not yet sunk at all deeply.

(*b*) The very great forward extension of the duct and its very unusual exit, practically on the outer surface and just behind the septomaxilla, are of interest. The duct only occurs in Tetrapoda, never in fish, and its origin is obscure; it may be suggested that it is possible that it has been derived from one of the lateral line canals so commonly found in Stegocephalia, of which there is no trace in *Micropholis*.

The jugal is very small; it lies along the upper edge of the maxilla, and its anterior end is united by a suture to the lachrymal. Its slender posterior end just meets the anterior end of the post-orbital in the middle of the lower border of the orbit, the two bones being covered outside by the maxilla.

The post-orbital is a very large bone forming a great deal of the posterior and lower borders of the orbit, having a very extensive suture with the maxilla and also touching the jugal and quadrato-jugal.

4. In the temporal region the three bones squamosal, intertemporal, and supratemporal are present. The squamosal has its usual relations, the sub-otic part of the bone sheathing the back of the quadrate and meeting the pterygoid. The other two bones are not in relation to any underlying bones and are remarkable in that the posterior bone, the supratemporal, is much reduced, covering a very small area

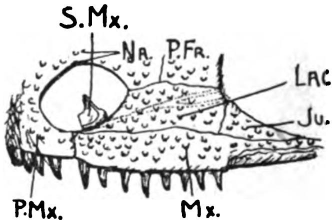


FIG. 2. *Micropholis Stowi.* Side of face. × 2. From a Geological Society specimen. The dotted lines in the lachrymal mark the course of the ductus naso-lachrymalis.

between the squamosal, intertemporal, and tabular. In every other Stegocephalian that I remember the intertemporal is the bone which is reduced, the supratemporal remaining large.

The palate (Text-fig. 3) is beautifully shown in Owen's type-specimen.

The basi-occipital has not been seen, but R. 510*a* shows well the two large exoccipital condyles, from above and the back. The basisphenoid is not well shown, but has large laterally directed basipterygoid processes with which the pterygoids articulate.

There is a large parasphenoid forming a plate much higher than wide, whose upper edge is channelled to receive the cartilaginous mesethmoid. The lower surface of the parasphenoid bears a double row of small backwardly directed sharp teeth.

The pterygoid articulates loosely with the basipterygoid process of the basisphenoid, sends a ramus, which consists of a deep narrow plate whose upper border nearly touches the roof of the skull, back to cover the inner side of the quadrate, and to articulate with the squamosal.

The rest of the bone appears in the palate, and its lateral border has a suture with the palatine.

There is apparently no transpalatine. The palatine is an extremely narrow slip of bone lying between the maxilla and the very large interpterygoid vacuity. It apparently bears three rather large teeth. Its inner border is in contact with the pterygoid behind and the prevomer in front, and its anterior border forms the back of the posterior naris.

The prevomers are large bones meeting one another in the middle line, articulating in front with the premaxillæ and forming the inner borders of the posterior nares, each of which is enclosed by a row of teeth.

All the individuals have the lower jaw present and tightly closed on the skull. The jaw is very slender, and the thin bones of which

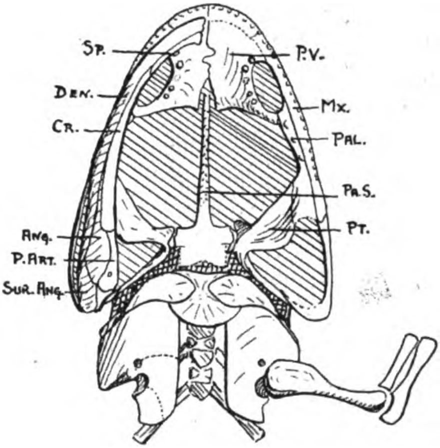


FIG. 3. *Micropholis Stowi*, Hux. Ventral surface of anterior part of skeleton. × 1. Skull from R. 510. Lower jaw from all material. Shoulder-girdle and vertebræ from a specimen in the Geological Society's Collection. *Ang.* angular; *Cr.* coronoid; *Den.* dentary; *P.Art.* prearticular; *P.v.* prevomer; *Pa.S.* parasphenoid; *Pal.* palatine; *Pt.* pterygoid; *Sp.* splenial; *Sur.Ang.* surangular.

it is composed have long overlaps: in development the ends of these bones are almost always pulled off with the matrix, but owing to the abundance of material it is possible to be quite certain of the structure.

The articular is well ossified, but not produced behind the articulation. Its inner side is covered by the prearticular, which extends forward below the supra-Meckelian vacuity on the inner side of the jaw for nearly half its length. In front its upper end rests against the dentary. The hinder end of the prearticular is pierced by a small foramen for the chorda tympani (seventh nerve). The outer side of the articular is covered by the surangular, which reaches so low down that it very nearly, if not quite, touches the prearticular.

The angular is a boat-shaped bone forming the lower surface of the jaw and overlapping the surangular and prearticular.

The dentary is a long bone extending from the symphysis far back, overlapping the surangular and angular, and towards the front forming the lower edge of the jaw.

The coronoid is a very large bone on the inner side of the jaw, reaching well forward and running back with a long overlap on to the angular and prearticular; in all regions it comes right down to the lower edge of the jaw.

The splenial is a small bone on the inner side of the jaw, which has a symphysis with its fellow, and passes backward, overlapping the coronoid.

The material does not show whether an epicoronoid was present or not, but if present it must have been small.

Vertebral column. R. 510*a* has fourteen vertebræ in a continuous chain behind the skull, which are exposed from the dorsal surface. Another specimen shows the ventral surface. The atlas is shown in R. 510*a*. The neural arch is in two pieces which meet or nearly meet in the middle line. They are large and carry the facets for the exoccipital condyles. Behind and below is a small pleurocentrum,

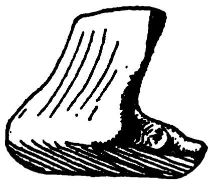


FIG. 4. Left scapulo-coracoid of *Micropholis*. × 1½. Geological Society specimen.

which articulates also with the neural arch of the second vertebra. The specimen cannot be cleaned sufficiently to show the intercentra in this region.

All the succeeding vertebræ are much alike; they are tripartite rachitomous vertebræ of very slender build.

The neural spines are of medium height and the zygapophyses slender and narrow from side to side. The anterior vertebræ have a strong transverse process carried on the pedicel; in succeeding vertebræ this becomes progressively shorter.

The pleurocentra are very thin plates of bone of which little can be said, and the intercentra are small wedge-shaped pieces of a cylinder bearing a special projection for the articulation of the rib.

The ribs are sufficiently described by Figs. 1 and 3, the more posterior ribs being similar but more slender.

The shoulder-girdle is very well shown in a specimen formerly belonging to the Geological Society. The cartilage bones of each side are fused into one mass in which the sutures shown dotted in Fig. 3 are only very doubtfully recognizable.

The scapula has a large thin blade quite smooth on the outer surface, and, if the sutures are correctly recognized, is turned inwards in front so as to form a horizontally placed sheet of bone on the ventral surface, which is continuous with the coracoid and precoracoid, which are wholly on the ventral surface of the animal. The scapula above the glenoid cavity is strengthened by the development of a strong buttress on its inner side near the posterior margin of the blade. This results in the formation of two deep pockets on the inner and posterior sides of the bone which are connected by the supra-glenoid foramen. There is also a 'coracoid' foramen in the suture between the scapula and the precoracoid. There is apparently no glenoid foramen. It is perhaps of interest that a glenoid foramen occurs in the majority of frogs, where I have observed it in the genera *Discoglossus*, *Alytes*, *Bufo*, *Megalophrys*, *Scaphiopus*, *Nototrema*, *Phyllomedusa*, *Hyla*, *Limnodynastes*, *Calyptocephalus*, *Leptodactylus*, *Ceratobatrachus*, *Rana*, *Breviceps*, *Callulops*, *Rhombophryne*, *Callula*, and *Cacopus*; it does not occur in *Pipa*, *Hymenochirus*, and *Xenopus*.

The interclavicle is a thin rounded plate of bone with no stem, and the clavicles are very slender, bent at right angles, and like the interclavicle scarcely at all ornamented. The cleithrum is not fully

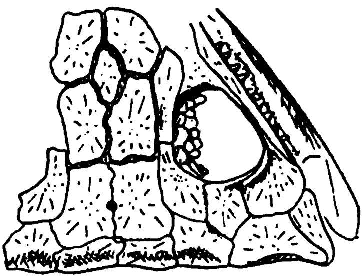


FIG. 5. Skull of ? *Ricnodon*, R. 2818. × 1. To show the interfrontal and the small dermal ossifications in the orbit.

exposed, but is, so far as seen, a very slender slip of bone lying along the front of the scapula; it seems to be certain that it was not continued up so as to form a cap over this bone, as in such types as *Eryops* and *Cacops*.

The humerus is a very remarkable bone; it has only slightly expanded ends, whose broad planes are at right angles to one another, and the deltoid crest is both slender and short. The radius and ulna are sufficiently described by the figures (Figs. 1, 3). The carpus is well ossified even in the young individual in which it is preserved, and the metacarpals and phalanges are little hour-glass shaped bones.

Dermal armour. No specimen, except Huxley's type, shows any of the scutes in position, but it is probable that the whole of the skin between the lower jaw and the clavicles was strengthened by a mosaic of small polygonal scales. I have seen no dermal ossifications behind the shoulder-girdle on either the dorsal or ventral surface.

One specimen shows a series of 'sclerotic' plates in the orbits; these are not well preserved, but seem to be restricted to the upper part of that opening and to have united by their edges to the upper border formed by the pre- and post-frontals and frontal. Comparison with the very similar series of bones in the orbit of the specimen of ? *Ricnodon* (Fig. 5) shows that these bones are not really in the eye at all, but are dermal ossifications in the eyelid corresponding roughly to the palpebral bones of crocodiles.

Micropholis Stowi comes from the *Procolophon* beds, the age of which, although not accurately known, is undoubtedly either Lower or Middle Trias. It is hence of much interest as the latest rachitomous Stegocephalian, of which much is known (isolated vertebræ were described many years ago by v. Meyer from the Lettenkohle of Wurttemburg). It is an exceedingly advanced type, as is shown by the following features:—

1. The unique arrangement of the bones of the top of the skull.
2. The enormous interpterygoid vacuities. I showed recently that the really primitive Amphibia (*Pteroplax*, etc.) have very small interpterygoid vacuities, and that enlargement of them is one of the chief lines along which the characteristic Amphibian as opposed to reptilian evolution takes place. They are larger in *Micropholis* than in any other rachitomous type, but, as in all members of that order, the pterygoids are articulated with the basisphenoid and not suturally united with the parasphenoid as in all *Stereospondylus* types.
3. The slender clavicles and great reduction of the cleithra, a parallel specialization to that common to the Reptilia.
4. The very slender humerus.
5. The loss of the grooves for lateral line sense organs.

Despite its many advanced characters, *Micropholis* is a comparatively unspecialized animal, free from the many bizarre features of such types as *Trematops*, *Cacops*, and *Dissorophus*. Its ancestors are unknown, and no types really closely allied to it have been found, so that it will have to form a separate and distinct family.

III.—*Psalidocrinus*: a new Genus of Crinoidea from the Tithonian of Stramberg.

By Dr. Mauric Remeš, Olomouc, Moravia, and Dr. F. A. Bather, F.R.S., British Museum (Nat. Hist.).

Papers referred to.

1891. Jaekel, O. "Ueber Holopocriniden, etc.": Zeitschr. Deutsch. geol. Gesell., vol. xliii, pp. 557–670, pls. xxiv–xliii.

1907. Jaekel, O. "Ueber die Körperform der Holopocriniten": N. Jahrb. f. Mineral., Festband, pp. 272–309.

1912. Remeš, M. "Nové zprávy o lilijicích z moravského tithonu": Zvláštní otisk z časopisu moravského musea zemského. Brno 1912. Ročník xii, čís. 1, pp. 157–169, pls. i–iii.

PART I. By Dr. M. Remeš.

The species *Eugeniacrinites strambergensis* was described by me in 1912 (pp. 161, 167, pl. iii, fig. 2) on the evidence of a single specimen (A). Examination of a better specimen (B), subsequently acquired, and believed to be of the same species, has convinced me that, though the species appears to belong to the family Eugeniacrinidæ, Zittel, still it belongs to none of the known genera. This new genus, it is true, resembles ***Apsidocrinus*** in the union of its interradial processes, which form a kind of vault above the patinal cavity (Jaekel, 1907, p. 304; Remeš, 1912, pp. 163, 168), but it differs from that genus in the form of the interradial processes, and especially in the size and shape of the radial facets.

Description of the Specimens.—(A) Holotype of ***Eugeniacrinites strambergensis*** (Text-figs. 6–8). The measurements of the patina are: height, *circa* 8 mm. [incomplete]; diameter at base, *circa* 5 mm.; diameter at upper margin, *circa* 12 mm. In the lower half the sides of the patina ascend almost vertically, but spread outwards rapidly in the upper half, till the level of the radial facets is reached. The interradial processes, of which two are partially preserved in this specimen, then ascend almost vertically, but with a slight inward bend, for a short distance. Their broken surfaces then bend rather sharply towards the oral pole, at the same time spreading out above the radial facets and then ending in a point, so that the outline of the whole cross-section somewhat resembles that of a spade in playing-cards (Text-fig. 6). The radial facets (Text-figs. 7, 8) are large and wide, with deep muscle-fossæ. In the upper part of the patina, wherever preserved, the interradial sutures are distinctly depressed. The patinal cavity is spacious. It was the resemblance of the patina and of the radial facets to those of ***Eugeniacrinites*** which caused me formerly to refer the specimen to that genus, and to compare it with ***E. armatus***, Zittel, and ***E. alpinus***, Ooster.

(B) Second specimen (Text-figs. 1–5). This also is a patina, and has the following measurements: height, from stem-facet to summit of interradial processes, 17 mm.; diameter at stem-facet, 4·8 mm.; diameter at level of radial facets, 16·4 mm. In external form this specimen resembles the holotype, except that the interradial processes are better preserved, one of them being almost complete. From this one we may infer that they were large and wide at their proximal ends, but thinner above. About the middle of their height they spread out on each side into a wing-like process. The interradial sutures are distinctly and deeply depressed, starting from about half-way up the patina. Radial facets (Text-figs. 3, 4) large, deeply notched; they stretch almost half-way up the interradial processes. On them may be observed a ligament surface, ligament fossa, axial canal, and the transversely elongate muscle-fossæ and articular fossæ.

In both specimens the external surface of the patina is smooth, with no distinct trace of any sculpture.

Diagnosis of Psalidocrinus (ψαλίς, ψαλίδος, a vaulted chamber; the name marks the resemblance to ***Apsidocrinus***). — Patina resembling that of ***Eugeniacrinites*** in external form, with stem-facet sometimes excavated, sometimes level, having a star-shaped mark round the lumen; interradial processes well developed, coalescing in their upper part to form a vault over the patinal cavity, large at the bottom, tapering towards the top, marked externally in their lower part by deeply depressed interradial sutures; radial facets large, reaching half-way up the interradial processes.

Genotype.—The evidence for this genus is presented by specimen B, which I believe to belong to ***Eugeniacrinites strambergensis***. But should specimen B ultimately be placed in a different species, then the species to which it is referred will be the genotype of *Psalidocrinus.*

From *Apsidocrinus* this genus differs chiefly in its large radial facets and in the different shape of the interradial processes. In my opinion it has been modified from *Eugeniacrinites* in the same way as *Apsidocrinus* has been modified from *Phyllocrinus*. This seems to be proved, not only by its external form and its flattened but spacious patinal cavity, but especially by the larger size and peculiar shape of the radial facets, which, as in *Eugeniacrinites*, reach far up the interradial processes.

It seems probable that the brachials of this crinoid resemble those of *Eugeniacrinites* in shape. I am, however, not convinced that the brachials described by Jaekel as axillaria of *Eugeniacrinites* really belong to that genus. On the contrary, I am inclined to ascribe to both *Eugeniacrinites* and *Psalidocrinus* such axillaria as resemble *Cyrtocrinus* in their articular surfaces. Among the isolated brachials as yet discovered, however, I am not able to identify any with those of *Psalidocrinus.*

Both the specimens herein described are in my collection, and were obtained from the marl layers of the white limestone quarry, "Obecní lom," in Stramberg, Moravia.

PART II. By F. A. Bather.

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Dr. Remeš, having paid me the compliment of entrusting me with the editing of his manuscript and with the preparation of the illustrations to his paper, has also been good enough to permit me to develop his specimens more than was possible for him. Although this led me to communicate to him certain criticisms, it seemed inadvisable to modify his manuscript to any great extent. Except, therefore, for a few measurements which I have taken the liberty of rendering more precise, Dr. Remeš remains responsible for the contents of his own paper.

The fixing on specimen B as the type of the new genus was due to my suggestion, and the present note is intended to show why that course seemed to me particularly desirable. In a word, I cannot readily agree with Dr. Remeš that his specimens A and B belong to one and the same species. The differences are as follows:—

The stem-facet in A is, as Dr. Remeš recognizes, markedly hollowed; in B it is flat. In A the ratio of the stem-facet to the greatest diameter of the patina is ·37; in B it is ·29. In A the outline of the facet is subpentagonal with rounded radial angles; in B it is subcircular. In neither specimen can I detect the "star-shaped mark round the lumen", but in B the joint-face is covered with irregular, anastomosing, rather obscure pustules, with a slightly radiating arrangement (Text-fig. 2); in A there are only some obscure depressions in the cavity, apparently interradial in position, but that is rather vague. It may be noted, by the way, that the plane of the stem-facet in B is a little oblique to the main axis (Text-fig. 1).

The lower half of the patina of A was described by Dr. Remeš (1912, p. 167) as 'cylindrisch', a phrase that he has permitted me to modify in his present description. Even this, however, does not go far enough to justify the statement that B resembles A "in external form". So far as measurements are at all possible, the actual facts are these: in the lower part of the patina the sides approach at an angle of 45° in A, of 80° in B; in the upper half of the patina the sides approach at an angle of 105° in A, of 108° in B. Therefore the lower part meets the upper part at an angle of 145° in A, of 166° in B.

The view of the patina from below (Text-fig. 2, and Remeš, 1912, pl. iii, fig. 2*c*) shows a clear difference of surface-modelling. In A the interradial depressions continue from the margin of the patina to the stem-facet; in B they continue only half-way, and each is then succeeded by a distinct interradial swelling.

The interradial sutures can be distinguished in A, but are by no means to be made out in B.

The view of the patina from above (Remeš, 1912, pl. iii, fig. 2*b*) shows in A a patinal cavity, which Dr. Remes rightly describes as spacious. He was unable to see the cavity in B, but I have convinced myself that it was far more restricted. A proof of this is given by the next observation.

A cross-section of an interradial process, just above the level of the radial facet, is given for A (Text-fig. 6) and B (Text-fig. 5). The difference of form, though not great, is sufficiently obvious. The difference of relative size is even more marked; in A the ratio of the interradial diameter of the process to the total diameter of the patina is ·33; in B the same ratio is ·43. This means that the diameter of the patinal cavity is less in B by 20 per cent.

The radial facets are described by Dr. Remeš as though they were precisely similar in the two specimens. They have, no doubt, the same general character, which, as he justly points out, approaches that of *Eugeniacrinus* rather than of *Phyllocrinus* and *Apsidocrinus*; but the differences between them are fairly striking. In A (Text-fig. 7) the radial groove proper is short and small, and little more than a tongue-like depression at the bottom of the wide V formed by the sloping upper borders of the muscle-plates; in B (Text-fig. 3) it is a deep U, of which the sides ascend almost vertically and meet the corresponding upper borders of the muscle-plates at an angle which approaches a right angle. The same difference finds expression in the far greater height of the muscle-plates in B than in A, and this height is due to an enlargement of the tract above the wide and deep muscle-fossæ. This tract bears the articular depressions which Dr. Jaekel (1891, p. 641, text-fig. 20) has named "Gelenkgruben", and has also shown clearly in his restorations of *Eugeniacrinus caryophyllatus* (1907, pp. 300, 301, text-figs. 21, 24). In A those depressions are almost imperceptible; in B they not only occupy a larger field (as just explained), but seem, from the evidence of the better preserved among the facets, to have been fairly pronounced. The difference between the muscle-plates of the two specimens is also apparent when the radial facets are viewed from above; in A (Text-fig. 8) the upper part of the muscle-plate projects right over the muscle-fossa, so as almost to cover the ridge which separates this fossa from that for the interarticular ligament; in B (Text-fig. 4) the whole plate slopes more inwards, so that this ridge is clearly exposed and the muscle-fossa itself is partly visible.

It follows from the differences in the radial facets that there was a corresponding difference in the arms.

From the differences in the patinal cavity and the relations of the interradial processes, so far as they are preserved, one may also infer that there was some difference in the portions of the interradial processes not preserved in A. Whether this difference was so great that the processes did not meet over the oral centre as they do in B and in *Apsidocrinus*, one cannot say. Dr. Remeš believes that they did so meet. In either case the large size of the interradial processes in A indicates an approach to the apsidal or psalidal character, and so far justifies Dr. Remeš in his removal of the specimen from *Eugeniacrinus*.

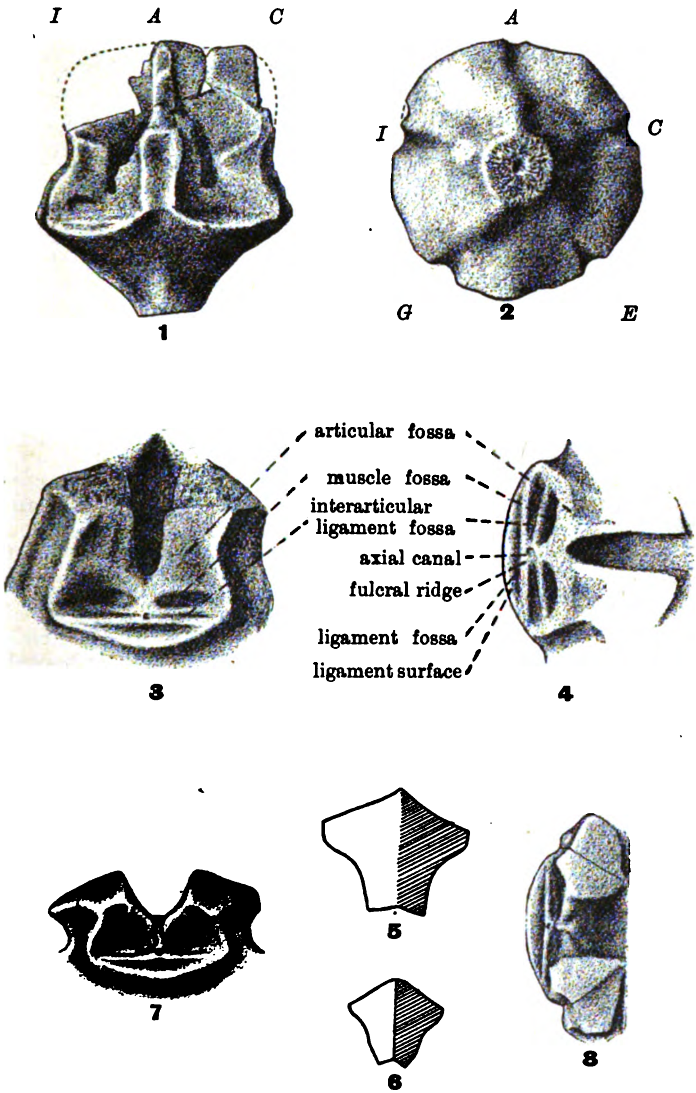
Time and opportunity do not permit me at present to make a thorough study of the numerous genera that have been established in the Eugeniacrinidæ since I last attacked the subject. Dr. Remeš believes that *Psalidocrinus* is a homœomorph of *Apsidocrinus*, having been modified from *Eugeniacrinus* in the same way as *Apsidocrinus* was modified from *Phyllocrinus*. But while it is fairly safe to associate *Apsidocrinus* with *Phyllocrinus*, it is by no means clear that *Psalidocrinus* is so intimately connected with *Eugeniacrinus*. The Eugeniacrinidæ, as restricted by Jaekel (1907), are distinguished *inter alia* by the very small size of their interradial processes and the correspondingly peculiar development of their primaxils, which can meet centrally over the patinal cavity. This line of development is the converse of that followed by the Phyllocrinidæ (Jaekel, 1907), in which the interradial processes are large and may meet centrally, while the primaxils are unspecialized. Therefore *Psalidocrinus* cannot well be derived from a Eugeniacrinid in Jaekel's sense. On the other hand, the large size of the radial facets justifies the contention of Dr. Remeš that *Psalidocrinus* is not a descendant of *Phyllocrinus*. We must therefore seek for an ancestor among more primitive Holopodidæ, such as *Sclerocrinus* and *Cyrtocrinus*.

Provisionally, at any rate, *Psalidocrinus* is to be accepted. But the principles governing our acceptance themselves render it difficult to place the genus in any one of the families as defined by Jaekel (1907). Logically, one ought to erect a new family for it, but until further evidence is forthcoming it is preferable to call it merely a Eugeniacrinid *sensu lato*.

It is, however, necessary to distinguish specimen B from specimen A. The latter is the holotype of *Eugeniacrinus strambergensis*, Remeš. Therefore I make B the holotype of a new species, *Psalidocrinus remeši*; and, in accordance with the express instructions of Dr. Remeš, that species is to be regarded as the genotype of *Psalidocrinus*. The conclusions of this note are summarized in the following diagnoses:—

PSALIDOCRINUS, Remeš.

A Eugeniacrinid with interradial processes stout and elevated so as to coalesce centrally over the patinal cavity. Radial facets wide,



PSALIDOCRINUS.

FIGS. 1–5. *Psalidocrinus remeši.*
,, 6–8. *Psalidocrinus strambergensis.*
FIGS. 1, 2, × $\frac{2}{1}$. FIGS. 3–8, × $\frac{3}{1}$.

horizontal, with muscle-fossæ deeply excavated beneath the muscle-plates. Patina below facets spreading, conical; interradial sutures depressed between facets.

Genotype. *Psalidocrinus remeši*, Bather, n.sp. (Text-figs. 1–5.)

A *Psalidocrinus* with flat stem-facet; depression of interradial sutures not extending to lower half of patina; radial groove of deep U shape, between elevated almost square-cut muscle-plates, which bear marked articular depressions.

Another probable species is—

Psalidocrinus strambergensis (Remeš). (Text-figs. 6–8.)

A (?) *Psalidocrinus* with excavate stem-facet; depression of interradial sutures extending to stem-facet; radial groove small, at base of wide V formed by upper borders of muscle-plates, which bear restricted and faint articular depressions.

The holotypes of both species are the only specimens yet known. Both come from the Tithonian of the Gemeindesteinbruch (Obecní lom), at Stramberg, Moravia, and both are in the collection of Dr. M. Remeš.

EXPLANATION OF FIGURES (p. 351).

SPECIMEN B. *Psalidocrinus remeši*, n.sp.

The interradii are lettered arbitrarily *A*, *C*, *E*, *G*, *I*, according to the method of R. T. Jackson.

FIG. 1. The patina viewed from interradius *A*. The processes in interradii *A* and *I* are imperfect above; that in interradius *C*, though fractured, is fairly complete. × 2 diam.

,, 2. The patina from below. × 2 diam.

,, 3. A radial facet, mainly based on that in radius *J*, but partly restored on the evidence of other facets. The interradial processes are broken above. × 3 diam.

,, 4. The same facet seen from above. × 3 diam.

,, 5. Section across interradial process *A* (accidentally broken during cleaning and subsequently repaired) just above the level of the radial facet. The uppermost point is adcentral. × 3 diam.

SPECIMEN A. *Psalidocrinus strambergensis* (Remeš).

,, 6. Section across an interradial process as in Fig. 5. × 3 diam.

,, 7. A radial facet. The interradial processes are broken above, as in Fig. 3. × 3 diam.

,, 8. The same facet seen from above. × 3 diam.

Drawings by A. H. Searle from the specimens and from sketches by F. A. Bather.

IV.—*Rochdalia Parkeri*, a new Branchiopod Crustacean from the Middle Coal-measures of Sparth, Rochdale.

By Henry Woodward, LL.D., F.R.S., F.G.S.

In the early days of geological investigation it was generally supposed that the soft parts of animals and their more delicate structures could not be found in a fossil state, but modern discoveries have entirely revolutionized our ideas as to what is capable of fossilization.

The researches of Professor Nathorst in Sweden and Dr. C. D. Walcott in America have made us acquainted with the forms of the soft-bodied Medusæ, the 'jelly-fish' of the Cambrian period, whilst Beecher and Walcott have discovered the long-desiderated most delicate branchigerous appendages of the Trilobites, and Dr. G. Holm the complete anatomy of *Eurypterus* from the Baltic Silurian. The soft-bodied Nereids have not only left their tracks, but their perishable forms pictured on the surfaces of the older rocks and the later Lithographic Stone. The indurated Chalk of the Lebanon reveals to us the bodies and tentacles of octopus and cuttle-fish, which had been already, but less perfectly met with in the earlier Oxfordian and Lias of England.

Of the Arthropoda of the Coal period, hundreds of new and beautiful forms of winged insects, in almost perfect preservation, have been figured and described by Charles Brongniart[1] and other workers, while numerous Crustacea have likewise been added to the marvellous fauna of this worldwide and most enchanting period of Carboniferous time.

Although many interesting forms of Arthropods from the Derbyshire Coal-field,[2] and from the Middle Coal-measures at Sparth, Rochdale,[3] and other localities,[4] have been already noticed in the GEOLOGICAL MAGAZINE, there are still several awaiting description.

The specimen I now propose to notice was kindly sent me, some long time since, by Mr. William Albert Parker, F.G.S., of Rochdale, who obtained it from the Middle Coal-measures, Sparth Bottoms, Rochdale. It is enclosed in a small clay-ironstone nodule, which, upon being split open, exhibits the impression and counterpart of the fossil. It measures 28 mm. in length and 10 mm. in depth, and presents an excellent side-view of the entire animal.

The head is short and rounded, and is produced downwards in a broad recurved beak-like organ, and is followed by eleven free body-segments, each supporting a pair of expanded recurved foliaceous

[1] *Insectes Fossiles des Temps Primaires, etc.*, par Charles Brongniart, 4to, Texte et Atlas, pp. 494 and 44, pls. 37, 1893. H. Woodward, "Orthopterous Insect from English Coal-measures": GEOL. MAG., 1875, p. 621. "Scorpion in Coal-measures": op. cit., 1875, p. 622. "Spined Myriopods": op. cit., 1887, p. 1. "Carboniferous Cockroaches": op. cit., 1887, p. 49. "*Euphoberia ferox*": op. cit., 1887, p. 116. "*Etoblattina Peachii*": op. cit., 1887, p. 433. "*Eurypterus*": op. cit., 1887, p. 481; 1888, p. 418. "New *Cyclus*": op. cit., 1893, p. 28; 1894, p. 530. "Crustaceans and Myriopods, Lancs": op. cit., 1905, p. 437. "*Cyclus Johnsoni*": op. cit., 1905, p. 490. "Fossil Insects, Coal-measures": op. cit., 1906, p. 25. "*Eurypterus*, Coal-measures": op. cit., 1907, p. 277. "Arthropods, Coal-measures": op. cit., 1907, p. 539. W. Baldwin, "Myriopods from Coal-measures": GEOL. MAG., 1911, p. 74.

[2] H. Woodward, "On *Eurypterus Moysei* and *E. Derbiensis*, Coal-measures, Ilkeston, Derbyshire": GEOL. MAG., 1907, pp. 277–82, Pl. XIII. "Ilkeston, Derbyshire": op. cit., 1908, pp. 385–96, with 9 text-figures.

[3] "*Pygocephalus* (*Anthrapalæmon*) *Parkeri*, Coal-measures, Sparth, near Rochdale": GEOL. MAG., 1907, pp. 406–7, Fig. 2. "Arthropoda from Coal-measures, Sparth": op. cit., pp. 539–49, with 5 text-figures. "On *Anthrapalæmon* (var. *Holti*), Coal-measures, Sparth, Rochdale": op. cit., 1911, pp. 361–6, with 1 text-figure. "Coal-measure Crustaceans, *Præanaspides præcursor*, H. Woodw., Coal-measures": op. cit., 1908, pp. 385–96.

[4] "On *Pygocephalus Cooperi*, Huxley, Coal-measures, Coseley, near Dudley": GEOL. MAG., 1907, pp. 400–7, Pl. XVIII.

swimming-feet (doubtless also branchigerous); the body is terminated by a pointed telson or tail-spine, giving origin to a pair of shorter lateral lamellæ from its base.

I have no hesitation in referring this unique specimen to the Branchiopoda.

In Sir Ray Lankester's Treatise on Zoology, 1909, ch. ii, p. 29, Dr. W. T. Calman, writing on the Crustacea, divides the sub-class Branchiopoda as follows:—

Order 1. Anostraca—*Branchinecta*, *Artemia*, *Chirocephalus*, etc.
,, 2. Notostraca—*Lepidurus*, *Apus*, etc.
,, 3. Conchostraca—*Estheria*, etc.
,, 4. Cladocera—*Daphnia*, etc.

Sub-order 1. Calyptomera (tribe 1, Ctenopoda; tribe 2, Anomopoda).
,, ,, 2. Gymnomera (tribe 1, Onychopoda; tribe 2, Haplopoda).

In this sub-class the carapace may form a dorsal shield, as in *Apus*, *Lepidurus*, etc. (the Notostraca); or a bivalved shell, as in *Estheria*, etc. (the Conchostraca); or it may be entirely absent, as in the specimen before us and in *Artemia*, *Chirocephalus*, *Brachinecta*, etc. (the Anostraca).

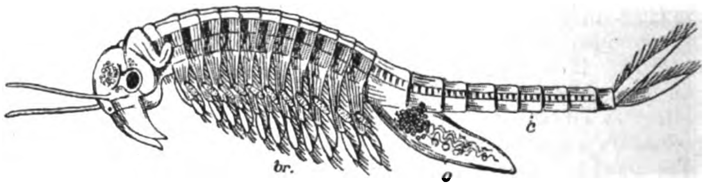


Fig. 1. *Chirocephalus diaphanus* (living freshwater). Enlarged three times nat. size. These animals always swim upon their backs. Reproduced (reduced) from Baird's *Nat. Hist. British Entomostraca*, 1850.

The range in time of the sub-class Branchiopoda is very great. Professor C. D. Walcott has figured an *Apus*-like form of Crustacean, *Protocaris Marshii*, in his "Fauna of the Lower Cambrian, or *Olenellus* zone" (Tenth Ann. Rep. U.S. Geol. Surv., pl. lxxxi, fig. 6). Professor T. Rupert Jones has figured *Estheria membranacea* (Pacht) (Pal. Soc. Foss. *Estheriæ*, 1862, p. 14, pl. i, figs. 1–7) from the Old Red (Devonian) of Caithness. Dr. Friedrich Goldenberg, in his *Fauna Saræpontana Fossilis*, 1873 ("Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken"), described and figured (Heft i, p. 23, Taf. i, fig. 15) six somewhat doubtful-looking segments which he attributes to *Branchipus*, and names *Branchipusites anthracinus*. The following is a translation from Dr. Goldenberg's paper:—

Of this animal eight segments are to be seen in profile; but of these, the first and last are very imperfect. The middle segments are also imperfectly preserved, so that one can only find indications of their segmentation. The lateral appendages (side-pieces or epimera), of which six are present, are pretty perfect in their natural connexion, and have much resemblance to the lamellar branchial feet of a *Branchipus*. Their anterior margin is somewhat incurved;

the hinder margin, which is parallel to the anterior, bends at about two-thirds of its length at an obtuse angle towards the apex of the anterior margin. In the middle of this oblique-inferior margin oval thickenings make their appearance, which I regard as remains of branchiæ which were attached here to the base of the lobe of the unjointed swimming-feet. The substance of these swimming-feet seems to have been membranous and of a blackish-brown colour.

This is the only record of a Palæozoic form of supposed Anostracan Branchiopod that I have met with.

I have, however, described an undoubted species referable to this division of the Branchiopoda (the Anostraca) from the Eocene (Bembridge) freshwater limestone of Gurnet Bay, Isle of Wight, which I named *Branchipodites vectensis* (see Quart. Journ. Geol. Soc., May, 1879, vol. xxxv, pp. 345–6, pl. xiv, figs. 6–10). It is interesting to mention that in this case both the males with their large clasping antennæ, and the females with small antennæ and egg-pouches, with large and very distinct disk-like bodies (the compressed eggs), can be seen distinctly in numbers upon the slabs of limestone from Gurnet Bay.

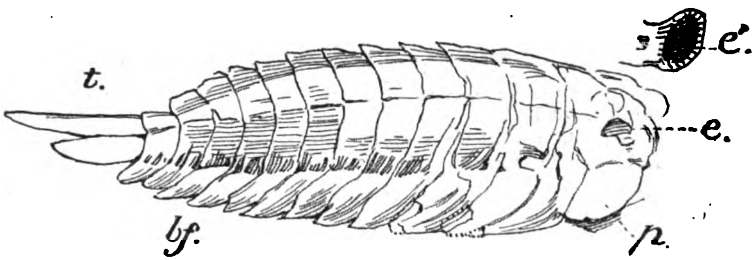


FIG. 2. *Rochdalia Parkeri*, H. Woodw., gen. et sp. nov. Middle Coal-measures: Sparth, Rochdale, Lancs. Enlarged three times nat. size. *t.* telson; *bf.* branchial feet; *p.* proboscis; *e.* position of eye; *é.* diagram of pedunculated eye (restored).

Description of the Rochdale specimen (Fig. 2).—The head, which is rounded in outline anteriorly, is 5 mm. in breadth and 9 mm. in depth, its widest part being the broadly expanded downward extension of the beak-like proboscis (*p.*).[1] The position of the eye (*e.*), which was no doubt pedunculated, as in the living examples of the Anostraca, is marked by the broken base of the peduncle; a suggested restoration of the eye (*é.*) is given separately above the head.

The four body-segments following behind the head are the largest, being equal in breadth to the seven succeeding segments, and they have also the longest recurved lobe-like swimming-feet (*bf.*); the seven hinder segments gradually diminish in depth backwards from 10 mm. to 5 mm. The segments are marked by a minute line, probably indicating the points of attachment of the branchial lobe to each of the swimming-feet; there is also a median dorsal line marked by a minute but distinct ridge, indicating the articulation of the body-segments to each other. The telson (*t.*) is 7 mm. in

[1] The proboscis is probably too small to indicate a male, but there is no trace of an egg-pouch to definitely fix the specimen as a female.

length, and is narrow and pointed, and its lateral lamella is rounder, shorter, and broader, being 4 mm. in length. The elongated posterior part of the trunk, which is without limbs, and which in *Chirocephalus* and *Branchinecta* makes up half the length of the animal, and consists of from seven to eight rounded segments destitute of limbs, is not developed in the Rochdale specimen; but in all the Branchiopoda the number of trunk-somites varies greatly (from eleven to nineteen in the Anostraca), whilst in the larval stages the number of segments is often much fewer than in the adult, especially as regards the apodal caudal segments. I think there is but little doubt that this specimen represents a mature individual, but bearing in mind the fact that it is of so great a geological age as the Coal-measures, one would not be surprised to find that it may have retained to some extent the larval characters of the family in its adult condition; the development of the caudal segments in later geological times may probably be the outcome of a more active lacustrine or pelagic life pursued by its descendants, and continued down to the present day.

The entire absence of a carapace, the form of the head, the probable presence of pedunculated eyes, and the general arrangement of the body with its branchigerous swimming-limbs, lead me to consider that its appropriate zoological place is with the Branchiopoda, and in the order Anostraca.

It may be convenient to suggest a new genus for its reception, and I would venture to propose the generic appellation of *Rochdalia* as a record of the locality which has yielded so remarkable and so rich a fauna; and *Parkeri* for the specific name, after its discoverer, who is one of the most enthusiastic of local collectors, and has added so largely to our knowledge of the Carboniferous Invertebrata of Lancashire.

V.—Notes on the Cretaceous Formation of Bahia, Brazil.

By Joseph Mawson, F.G.S.

(WITH A SKETCH-MAP.)

The Cretaceous formation of Bahia, first brought prominently to notice by the discoveries of Allport[1] in 1859, has been in great part examined and described by the late Professor Hartt,[2] by Dr. O. A. Derby,[3] by Dr. R. Rathbun,[4] and by Dr. J. C. Branner.[5] Some additional observations made by the present writer were published in the Geological Society's Journal of May, 1907, to accompany Dr. A. Smith Woodward's paper on the Vertebrate Fossils of the formation.

[1] S. Allport, Quart. Journ. Geol. Soc., vol. xvi, p. 263, 1860.

[2] C. F. Hartt, *Geology and Physical Geography of Brasil*, 1870.

[3] O. A. Derby, "A Bacia Cretacea da Bahia": Archivos do Museo Nacional, Rio de Janeiro, vol. iii, p. 135, 1878.

[4] R. Rathbun, "Observações sobre a Geologia. Aspecto da Ilha de Itaparica": ibid., p. 159.

[5] J. C. Branner, "The Stone Reefs of Brazil": Bull. Mus. Comp. Zool. Harvard Coll., Geological Series, vol. vii, p. 150, May, 1904.

The Map now given (p. 360) shows the Cretaceous formation along the coast of the bay from Montserrat as far as Toque Toque, i.e. the district adjacent to the city of Bahia, and it is offered, with a few further notes, as an aid to any observer who may have opportunity and inclination to take up work which the writer has now had to relinquish.

Association of Fossil Mollusca with Fossil Vertebrate Remains.

Amongst other instances noted are the following:—

Towards the Montserrat end of Pedra Furada Bay three parallel bands of limestone stand out distinctly in the cliff and on the beach. Scales, teeth, and bones of fishes associated with shells of the univalves common to the other beds of this series are found encrusted in places in these bands. The shale between them contains *Estheria*, etc.

Immediately underlying the lowest of these limestones is a thick bed of dark-blue shale, which also contains scales (of two or more species of *Lepidotus*) and other fish-remains associated with molluscs (*Anodonta*, *Paludina*, *Melania*, etc.). This same shale has also yielded a tooth of a Pterosaur, and contains a fine-textured thin greenish layer, with a lustrous surface showing numerous small delicate bones, with shells of molluscs and Ostracods.

In a thin bed of shaly sandstone, a little nearer than the above to Pedra Furada, all the smaller shells are found in abundance, and with them I have discovered small scales and teeth of *Lepidotus*, etc.

Between Pedra Furada and Bomfim a blue shaly mudstone has yielded a portion of a large scale of *Lepidotus*, associated with shells (not specified). A limestone near here full of shells (*Melania*, etc.) has yielded fragments of bone or teeth. A long slender species of *Melania* appears to be new and undescribed.

A little above km. 4, Bahia and San Francisco Railway, in an inlet of the bay, *Estheriæ* and Cyprids are found in a bed of shale with *Megalurus* and other fish-remains.

At km. 7½, on the beach, in a blue shale under conglomerate, a small *Planorbis* is found amongst an abundance of Entomostraca, and this shale contains also teeth of crocodile and a variety of scales, bones, and teeth of fishes, etc.

At Setúbal the interstratified gravels and mudstones contain various teeth, large and small, of reptiles and fishes; scales, etc., of fishes; and with them I have observed a mollusc (*Paludina*).

Km. 78–82. Cuttings on the railway line here show a soft yellow shale, bearing shells and a few fish-remains. The shells agree with those from San Thiago.

Km. 86, San Thiago. Over a tough drab-coloured shale, nearly unfossiliferous, lies a softer mellower shale containing *Anodonta* and other shells, and immediately overlying this is a bone-bed crowded with vertebrate remains.

At Ponto de Matuim, across the bay by canoe from Mapelle station (km. 22), there is a hard grey stone in reefs, with fossil remains of fishes and Entomostraca in various beds.

On the beach beyond Toque Toque is a highly fossiliferous rock (which may be compared with that of Mapelle Quarry), composed of angular fragments of stone in a hard matrix; it contains scales of *Lepidotus*, teeth and other remains of reptiles and fishes, shells of *Paludina*, and *Melania* of two species or varieties (one long and slender, probably not yet described). The shells are often finely weathered out in cavities of the stone.

Raised Beach near Toque Toque.

This recent raised beach, discovered by the writer in 1880, is well described and figured in Dr. J. C. Branner's work, p. 150, and is referred to here on account of the shells with coral of which one stratum is mainly composed. A few specimens of these are in the British Museum (Nat. Hist.), but more should be obtained, as they would probably indicate the period of the latest upheaval of the coast on the bay.

It will be seen by the map that this raised beach appears at intervals nearly as far as Plataforma station, following the sinuosities of the present coastline.

Beach, Bomfim to Pedra Furada.

The Cretaceous cliff between these two points was thought to be barren of vertebrate remains, but shortly before the writer left Brazil a thin layer rising from the beach was found to be rich in fossil fishes of various species in an extremely fine state of preservation.

There seems to be no reason why other layers should not be fossil-bearing, and the locality requires to be more fully explored; but care is necessary in wet weather, when falls from above are likely to occur.

Mapelle Quarry near north end of Tunnel.

The highly fossiliferous beds exposed in this now disused quarry were first made known by Dr. O. A. Derby, and are fully described in his "A Bacia Cretacea da Bahia" (1878). I have nothing to add, except that the top soil has been (I believe since he wrote) to a large extent removed, laying bare the petrified bed of what in Cretaceous times must have been a running stream, with the groovings, ripple-marks, and half-embedded pebbles standing out in sharp relief, thus confirming Derby's suggestion as to the origin of these deposits.

Plataforma to Itacaranha.

Portions of the blue shale on the beach here are often removed by the south-westerly gales in the winter months, April to June, laying bare a thin layer of a greenish hue, which is more than usually rich in fossil remains.

Here, as well as at Pedra Furada, concretionary limestone nodules are found in the shale. A sharp blow will occasionally disclose fishes or other remains in a fine state of preservation. Boulders of this limestone exhibit fossil bones, etc., but they are very difficult of extraction owing to the close texture and hardness of the stone.

A blackish shale met with on the Plataforma beach seems to be almost barren of remains.

Reappearance of Strata.

The formation at Setúbal, consisting of pebbly shale, sandstone, and loosely compacted gravel, rolled or gritty, intermixed with layers of yellow and blue mudstone, is exactly reproduced about 2 miles further along the beach at the last headland before San Thomé de Paripe, and in both places is fossiliferous, containing crocodilian and other teeth, scales of fishes, etc. There is a considerable resemblance to these in the beds under the fort at Montserrat, and again in those between Plataforma station and the viaduct, which are likewise fossil-bearing.

Tertiary Sandstone.[1]

Boulders of this coarse gritty brown sandstone are found also on the *taboleiros* on the Timbó Railway, beyond Alagoinhas as far as km. 33. The writer has examined many hundred blocks of this stone at Sitio Novo and other localities, but has failed to find any trace of fossils except, on one occasion, what appeared to be the impression of a reed or other coarse plant. Some of these boulders have smooth cylindrical holes an inch or more in diameter and a foot or more in depth, which generally occur singly. Their origin is unknown.

Periperi Tunnel, north end. Km. 11–12.

A black modern sandy soil, full of shells of molluscs, about 15 feet above the present beach, calls to mind an apparently similar formation in the island of Itaparica described by Mr. Rathbun; and in view of the interesting particulars given by him it is probable that the Periperi bed would repay the labour of a closer examination. Some of the shells are in the British Museum (Nat. Hist.).

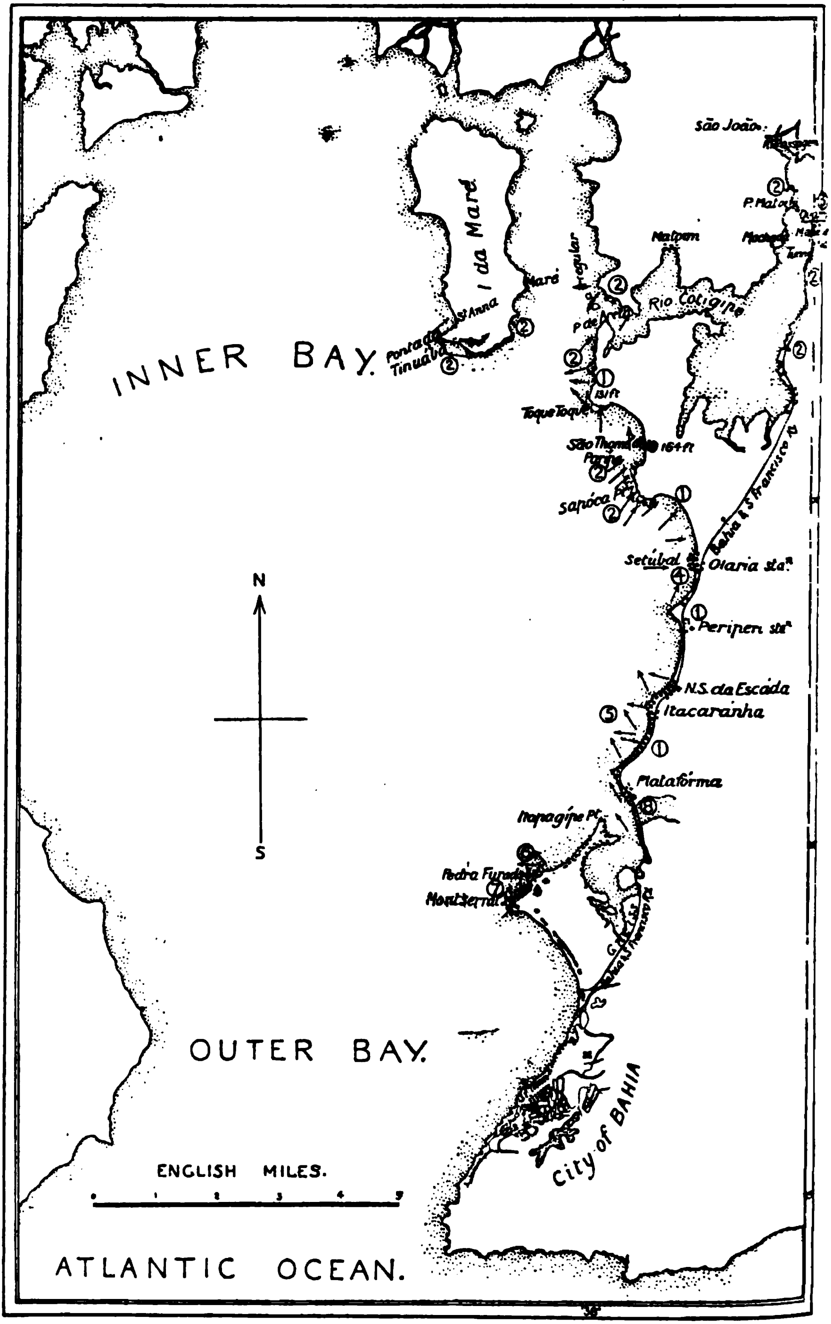
Cretaceous or Tertiary.

Above Agua Comprida station, km. 30 to 69 (Matta S. João), the formations met with on the line are, in general, Tertiary or Post-Tertiary, as described by Hartt; but the following occurrence appears to be doubtful: Above Camassari, at km. 50, a cutting shows a heavy bed of decomposing conglomerate, resting apparently on a kaolin-like clay, and from this place to km. 59 there are various exposures of the same decomposing conglomerate, overlying compact, sometimes clayey sands, purple, yellow, and pink, with a north-west or west dip. Above km. 60, beyond Feira Velha, there is a remarkably clear outcrop, about 20 feet high, of these variegated friable sands in well-defined parallel layers of from 6 or 8 inches to 3 feet, in the following order—

Bright warm yellow sand.
Purplish clayey sand.
Cool yellow sand.
Dark-pink (thin) muddy sand.
Reddish sand.
Yellow sand.

These bands have a very clear strong dip west to north-west. If more recent than Cretaceous, they seem to be worth describing on that account. I have not found fossils in any of the strata or in the

[1] See Hartt, op. cit., p. 367.



Map of the Coast around Bahia Bay, Brazil.
The localities referred to in Mr. Mawson's paper are all numbered on the map.

conglomerate, but, for want of opportunity, they have not been closely examined.

Pitanga Station Cutting.

This cutting is figured and described in Hartt's *Geology and Physical Geography of Brazil*, p. 368. The pink and white shale marked *g* has been found to contain several species of molluscs, some of which have not yet been found elsewhere. Specimens of these, not well preserved, are in the British Museum (Nat. Hist.), South Kensington. These strata are well worthy of further exploration. The contour of the cutting has been altered in late years.

EXPLANATION OF SKETCH-MAP (p. 360).

⟶ Indicating direction of dip of Cretaceous rocks as seen on the coast.

1. Exposures of recent Raised Beach.
2. Remains of reptiles and fishes, usually associated with Entomostraca and molluscan shells.
3. Quarry with numerous reptilian remains and fish-scales.
4. At Setúbal Point teeth of crocodiles are numerous, with small teeth and scales of fishes, and *Paludina*.
5. In the shales, limestones, and conglomerates between Escada and Plataforma numerous remains of reptiles (Crocodilia, Dinosauria, and Plesiosauria) and fishes (*Mawsonia*, *Lepidotus*, *Belonostomus*, *Diplomystus*, *Chiromystus*, *Acrodus*), with numerous molluscan shells and badly preserved Entomostraca.
6. In a high cliff a rich bone-bed with well-preserved fish-remains.
7. In the shales and limestones between Pedra Furada and Montserrat numerous remains of reptiles and fishes associated with molluscan shells and Entomostraca. A Pterosaurian tooth found here. Remains of reptiles and fishes also in the conglomerate at Montserrat.
8. In an inlet at km. 4, shale with Entomostraca and fish-remains (*Megalurus*, etc.) was met with.

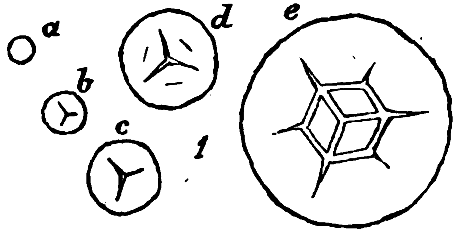
VI.—More about Septarian Structure.

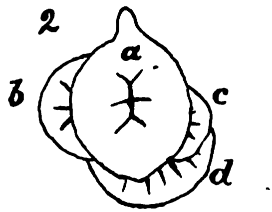
By J. E. Todd, M.A., Assistant Professor of Geology and Mineralogy, University of Kansas.

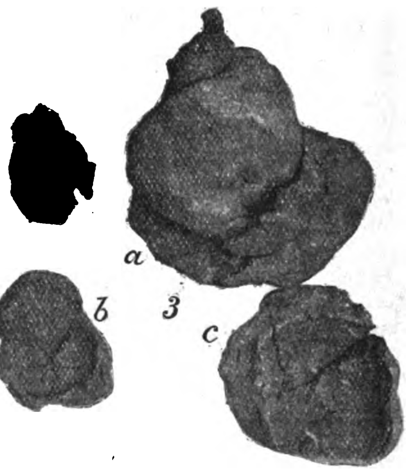
In his article on septarian structure in the March number of the Geological Magazine Dr. A. Morley Davies seems to call for further light upon the subject, hence the following is offered. The writer became convinced of the fallacy of the current teaching concerning the formation of concretions with cracked interiors and of septaria more than thirty years ago, and has so taught in his classes ever since. In 1902 he published a paper on "Concretions and their Geological Effects",[1] which presented facts which virtually demonstrate that the cracking is due to the expansion of the exterior rather than by a contraction of the interior, as Dr. Davies has also concluded.

The clearest evidence was obtained from compound concretions in the loess of Eastern Nebraska, of which illustrations are given. Simple concretions abound there, and uniformly whenever they are over an inch or two in diameter they are cracked inside. From them there is little instruction on the point under discussion except that the interior is of the same composition as the exterior, viz. fine silt cemented with carbonate of lime. There is not more of clay in the

[1] Bull. Geol. Soc. Am., vol. xiv, pp. 353 ff.







FIGS. 1*a–e*. A series of drawings illustrating the growth of a concretion having cracked interior, caused by the expansion of the exterior by more rapid interstitial deposition in that portion.

FIG. 2. Diagram of a compound calcareous concretion from the Loess of Eastern Nebraska. The different members were doubtless added in the order indicated (*a–d*).

FIGS. 3*a–c*. Photographs of fragment of such a concretion.

cracked portion, as the old theory postulated. The compound ones, on the contrary, are very instructive. They show apparently successive additions made on one side after another and sometimes one overlapping another, as in Figs. 2 and 3. To explain them by shrinking we must assume that small bodies of very contractile material had been mixed with less contractile in curious lenticular shapes by some inexplicable process. And if that be admitted, the cracks should be widest in the centres of the respective contractile members, whereas the facts are that the widest part of each crack is toward the centre of the whole. And the centre of the concave or inner side of each addition is evidently lifted away from the one under it.

By a further study of Figs. 2 and 3 it will appear very clearly that the most obvious and easy explanation is that there is first a collection of molecules of calcium carbonate in the pores of the silt around some nucleus, but the conditions are such that the deposition is not entirely at the surface, but largely in a shell reaching to a considerable distance below the surface. After the concretion has attained a certain size the centre will cease to receive additions to its mass, while the outer shell will continue growing both radially and tangentially, with force not only sufficient to crowd back surrounding and superincumbent material, but to also rend asunder the interior.

Should this seem incredible, let us remember the power of molecular attraction manifest in the tensile strength of wire, or in the supporting strength of rock, or of steel. In all cases it is the attraction of molecule for molecule, the apparently opposite directions in which it is manifested being due to different mechanical relations. The power of freezing water and the capillary action of water in wood which was used by the ancients for splitting rock are also illustrations of similar forces.

It may be noted further that the first cracking of the interior takes place when the thickness of the growing shell is several times the diameter of the ruptured interior, and that the cracks spread gradually toward the surface which they may eventually reach. When that is attained, water charged with various minerals will enter and begin filling the crevice. When lined with crystals they constitute a form of geode; when perfectly filled with crystalline matter, a true septarian.

Professor N. S. Shaler appealed to similar action in the formation of geodes of the common form, and also ascribed the filling of many veins to the expanding effect of crystallizing minerals.[1]

Dr. Davies argues in his paper that we should not hope to find effects of the expansion of the concretions in the surrounding shale because the compression of the shale was subsequent to the growth of the concretion. That may be true in some cases, but the writer has frequently noted in the shaly clays of the Pierre formation in South Dakota a shell of cone-in-cone structure surrounding large concretions of the sort under discussion. He has considered this a direct effect of the growth of the concretions.

[1] "Formation of Dikes and Veins": Bull. Geol. Soc. Am., vol. x, pp. 253 ff.

This expansive power of crystallizing or solidifying minerals may be credited also with the formation of those problematic structures known as 'stylolites' or 'lignilites'.

Given a horizontal film of some impervious substance in a mass of calcareous mud, hard particles above or below it to serve as nuclei for the deposition of calcareous material from one side only, and we should expect that this force of expansion in solidification would force a nucleus below the film upward and one above the film downward, simulating exactly what we find in 'stylolites'.

In closing, the writer would allude to another observation which seems to point in the same direction. He has often received drillings from artesian wells. When they have been put wet into glass bottles he has frequently found some of the bottles broken in drying. So far as tests were made, all those broken were found to contain matter highly calcareous, while those unbroken were sand or clay without calcareous material.

VII.—Geological Notes on a Human Skeleton found in Silt at Savonas, British Columbia.

By Geoffrey F. Monckton.

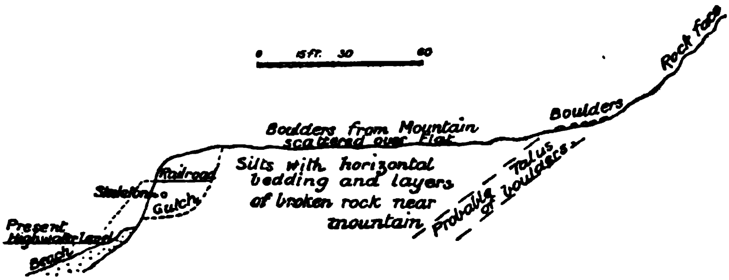
In the early part of 1910 I noticed some bones projecting from a cliff near the foot of Kamloops Lake, B.C. The cliff is composed of silt, and belongs to the formation known as the White Silts. These belong to the Quaternary period, having been laid down during the retreat of the great glacier. They stand in very steep banks, which is partly due to the small rainfall, only 7 inches, in this district. Little streams of water from melting snow, collecting in a hollow on the flat behind, had been for three years or so gradually cutting a fissure, and it was in the side of this fissure that these bones appeared. Some cutting down of the face of the cliff to bank up the trail exposed them more, and at the end of the year a road was made up it and we took them out. The silt is very definitely laminated. There are also a few seams of fine pebbles through it. One of these actually touched the bones. None of these seams or laminations showed any sign of movement of the ground. Had the bones been put in from the top it would have necessitated a hole 12 feet deep. A fissure would have left its mark on the seams of pebbles. People have been living along the beach in front of the cliff since 1860, and at that time the face of the cliff must have been at least 8 feet farther forward, as it has not only been constantly cut back from time to time in order to bank up the trail, but a good deal was taken away in the early eighties to level sites for houses. The bones must therefore be of the same age as the silt.

The silt is very dry, and contains a small quantity of lime. It should therefore be a good preservative medium.

As to its position, the bones of the body were all bunched together, the legs stretched forward, and the skull close to the knee, as if the body had rested in the soft mud in a sitting position, and, as it decayed, the bones had fallen together. I should imagine that its owner was drowned very likely by falling through thin ice. There were no implements whatever found with the skeleton. Unfortunately the lower jaw is missing, but most of the other parts of the skeleton were found. A careful search revealed no teeth. During the following summer the Canadian Northern Railway laid a track across the spot in my absence.

I submitted this skeleton to Mr. Charles Hill Tout, who is well known for his ethnological work in connection with the British Association and who has made a special study of prehistoric man in British Columbia, and I quote from him as follows: "It was the skull of a mature person. All the sutures had coalesced. The type is also markedly dolichocephalic, the cephalic index being about seventy-five. In stature the individual was short, not much over 5 feet, and the ridges on the tibia or shin-bones are less sharp than those of modern man."

The bones are now in the hands of the specialist attached to the Canadian Geological Survey for examination. The exact point of discovery was about three hundred yards above the Thompson River Bridge, at the foot at Kamloops Lake, on the north side. It is about a mile from Savone station on the C.P. Railway.



Section showing position of skeleton in silts at Savonas, British Columbia.

Briefly, the later geological history of this district is as follows. During the Glacial period, the elevation was much greater than it is now. At the end of that period, the land gradually subsided as the ice receded. Dr. G. M. Dawson seems to think that it subsided to a depth of 4,000 feet below the present level, but I venture to differ as to that, and consider that 1,000 feet would be quite sufficient. After that it was again uplifted to its present position. Many large glaciers still remain in the country, and anyone who has travelled much in the higher mountains will realize that a greater snowfall or uplifting of the land would cause a great extension of the glaciers. A very complete description of the White Silts is given by Dr. G. M. Dawson, who named them, in vol. vii of the Canadian Geological Survey Reports. From this I quote: "It is probable that we may place the upper level of the Silt formation in this region at about 2,500 feet, though it is still apparent that the more important developments of the deposit lie below 1,700 feet. The Silt deposits are found in this part of the interior plateau down to less than 1,000 feet, but it is possible that some of the lower-level deposits have been secondarily formed from the denudation of the higher.

"In the valley of the South Thompson the Silt formation is most characteristically represented, forming, as before stated, broad terraces or benches along the sides of the valley, with the surfaces gently sloping towards its axis, where the river has formed for itself a deep subsidiary channel. In some places, as above Kamloops on the south side of the valley, the edge of the White Silt bench has been cut up by little streams descending at times from its summit into complicated and ragged ridges. The eroded faces are always very steep and occasionally vertical, and in the sunlight have a peculiar glossy shimmer due to the great abundance of particles of mica, which when the bank is wet become arranged parallel to its surfaces, and on drying adhere in that position. The bedding is generally almost or quite horizontal, and layers of a few inches in thickness succeed one another with great regularity. The deposit is remarkably fine throughout, and no boulders or stones so large as to imply the action of ice were seen.

"These White Silts very often rest directly upon the boulder-clay. They are generally fine and uniform in texture and are usually well bedded in perfectly horizontal layers of 1 to 2 or 3 inches in thickness. Where occasional sandy or gravelly layers are intercalated these are attributable to local causes, being most frequently found opposite the mouths of valleys down which streams have flowed. The silts have evidently been laid down as a rule in tranquil water of considerable depth, and their material has as obviously been supplied by streams or rivers discharging from glaciers not far removed."

From the general correspondence in elevation between this and other deposits in the Cordilleran region and the Red River Valley he draws the conclusion that the inland lake in which these silts were formed was connected with the sea, and "governed in its level by that which the sea held at the time". It does not appear to me that this was so. If it had been, one would expect to find beaches with marine deposits on the coast at much higher levels than that at which they have been found, which does not exceed 200 feet. I think we may find sufficient reason for the formation of a large inland lake which would include the valley of the North Thompson for 100 miles north of Kamloops, and the South Thompson Valley from a short distance below the Little Shuswap Lake to below Spences Bridge, about 125 miles more, with some tributary valleys. This reason is the narrowing of the outlets through high mountain ranges which would result in the blocking of the channel by the meeting of glaciers from the two sides. As to the outlet leading to the Fraser, at Gladwin the 4,000 ft. contour-lines on opposite sides of the Thompson are only 2½ miles apart, and at the 3,000 ft. 1½ miles. Sixteen miles further up the river, near Spences Bridge, the difference is barely 2 miles at the 3,000 ft. level, and less than 3 miles at Pukaist, which is 8 miles higher up. At the 2,500 ft. level they are a mile and a half apart at the first two points and scarcely over 2 miles at Pukaist. From Spences Bridge to below Gladwin many summits of 5,000 feet and over occur within a mile of the 3,000 ft. level, so that no great stretch of imagination is required to block this outlet with glaciers from the heights above up to the 2,500 ft. level long after they had retired from the more open part of the district. As the river cut down, it must also have been temporarily affected by serious slides in this gorge. Even since white men came to this country the river has been completely blocked on occasions by slides, and was once raised 70 feet. There is another outlet immediately south of Kamloops, where the distance between the two contours at 3,000 feet is 2 miles, and also one leading into it from the head of Cherry Creek, which is less than a mile, but this is above the 2,500 ft. line, and so is the narrower valley of Campbell Creek into which these lead. In this region also there are several high mountains from which local glaciers would descend till a late period.

The main part of the water of this lake would therefore very likely have to find its way eastward by Little Shuswap Lake, whence it would pass through the Greater Shuswap Lake either through the very narrow Eagle Pass, 1,840 ft. elevation, into the Columbia, or in larger quantity into the Okanagen through a pass 1,196 feet above the sea. At several points on its course it would probably be greatly restricted by glaciers from the mountains close by. It would also be considerably impeded at certain seasons by icebergs breaking away from glaciers on the edge of the water, especially in the earlier stages of the recession and stranding of the ice in the channel. These outlets that I have mentioned would have to carry away the water from a district covering about 12,000 miles, and probably the Little Shuswap would be the only one available. It is estimated that the ice covering this region was in many places 6,000 feet thick. Since its general direction was south-eastward, it must have been 5,500 feet thick at Kamloops Lake, as it had to cross a mountain range to the south, which averages over 4,000 feet above the sea. Kamloops Lake level is 1,110 feet elevation at low- and 1,138 at high-water mark.

The time which has elapsed since burial of the skeleton I estimate as follows. I calculate that the silt and gravel which would be deposited in the area now occupied by Kamloops Lake and six miles west, and two miles east of it (comprising with its tributary valleys about 150 square miles), would be drawn from a region extending 35 miles north and 10 miles south, with a length of 25 miles. This would cover 1,125 miles, of which the probable average area covered by glaciers during the period of their retreat would be at least 500 square miles. The area to be filled may for purposes of the calculation be divided into a lower trough below 1,500 feet, a middle stage up to 2,000, and an upper level up to 2,500 feet above sea-level. The lowest would cover 50, the upper 150 square miles.

Basing our calculation on the Muir Glacier discharge as measured by Professor G. F. Wright, of one-third inch over the whole area covered by the glacier annually—

	Years.
One-third inch on 500 square miles would fill lower trough of 50 square miles in 1,800 years, and from just below the 1,200 ft. level in	1,100
One-third inch on 500 square miles would fill the middle stage up to the top and provide sufficient for the deposition of silts in all the sheltered bays up to 2,500 feet in	7,200
Total number of years for deposition of silts since burial of the skeleton	8,300

In making this estimate we must remember that the time would probably be much less: (1) because of frequent slides from the mountains, which would fill many places with local material; (2) because when the great glacier covered all this region and was travelling over high ridges it would naturally tend to leave deposits of boulder-clay at several points in hollows, or in places where on account of the flattening of the grade it could not exert much pushing power, and as the glacier retreated these deposits would be very quickly reassorted by the flooding waters. It appears to me that for these reasons the above figures might well be reduced by 1,500 years.

	Years.
Without making such an allowance, there would have elapsed since the burial of the skeleton	8,300
If we allow 2 feet in ten years as the average rate for the cutting down of the silts when the land began to rise from the 2,500 ft. level to the water-level in Kamloops Lake, the outlet would be reduced to 1,140 feet in less than 6,800 years (high-water mark is 1,138 feet)	6,800
Total number of years since burial	15,100

The rate of cutting down would probably be much greater: (*a*) because silt deposits above 2,000 feet would not be universally distributed; (*b*) on account of the rush of water which would follow the removal of dams in the narrow gorge to the west near Spences Bridge; (*c*) the uplifting of the land, say 1,000 feet; (*d*) the lake has now cut down so low that the grade of the river below it is only 10 feet to the mile, and therefore its excavating power is very small now compared to what it must have been. I should make a further deduction of at least 1,500 feet for these reasons.

The cutting down has not been carried on at an even rate, since it is evident from the appearance of terraces and old shorelines in the valley that the level of the water has at times been almost stationary and at others it has been lowered with a sudden rush, due probably to the breaking of dams and in some part to the elevation of the land. These two deductions would reduce the total to 12,100 years. There is also another possible reduction to be made. These calculations have been founded upon the theory that the whole lower trough of the valley was filled by the silts. There is an argument against this, which is, the peculiarity (referred to by Dr. G. M. Dawson in several papers) that the greater part of Kamloops Lake is evidently a rock basin, 400 to 600 feet deep. If it was once all filled with silts, how could it be excavated? If we assume, however, that the silts were simply deposited in limited areas, each area fed by its own river system, the explanation appears simple. We should then have the silts of the Deadman River extending westward from its mouth and eastward about 3 miles up the lake, where the water is shallow, except where there is a current which must have been stronger in the past. There would be found further up the Deadman where the stream was more rapid a development of gravel, which is the case, and as the river built up its delta and the glaciers receded, the silts would be laid down farther back on a higher level, as may be seen now near Criss Creek. There would be a small local development of silts at the mouth of Copper Creek at points where there would be but little current, and a large area at the mouth of the Cherry Creek valley and also at the Tranquille River, where there are actually large exposures of the silts at the mouth and contemporaneous gravels higher up (see Dawson's Report, vol. vii, Geol. Survey, as to this last). If this theory be adopted, and it has always seemed to me the correct one, it would explain why some 10 miles of this lake average over 400 feet below the present outlet, which outlet itself is not more than 20 feet above bed-rock showing now in the river below. The only other possible explanation of this hole it that it was excavated by ice, but if so, why did the ice leave the silts untouched at the lower end of the lake? and there is no trace of such ice. Shuswap Lake to the eastward has the same peculiarity, namely, a rock basin with deltas of silt and gravel close to it, showing no silt along its sides except where it might be locally derived. Should this surmise be correct, another 3,000 years might well be taken off the 12,100, leaving only 9,100 years.

To my estimates it will no doubt be objected that they are based on too high estimates of glacier work. It is true that researches such as those of Dolfus Ausset on the Unter Aar Glacier premise a much slower rate of glacial deposit and erosion, but against this there are several arguments. The first is that his observations were drawn from glaciers descending from mountain peaks. Now, the fundamental reason for the existence of a mountain peak is that it is composed of the hardest material in the district. Therefore an estimate of erosion based upon work done under such conditions is certain to be very low, much too low for calculation of the work done by an ice-sheet crossing all kinds of rock-formations. Then, again, to estimate the work of ice-sheets covering hundreds and thousands of square miles by that which is done by glaciers of such limited area is very deceptive. Therefore I put aside his calculation of 0·6 of a millimetre eroded yearly by the Unter Aar Glacier as useless for our purpose.

When we compare the movement of the little glaciers of the Alps with that of the great ones of Greenland we find that while those of Switzerland move at the rate of 3 feet daily, that of Jacobshavn Fiord, 2½ miles wide, moves 60 feet a day according to Helland, and Rink estimated the movement of the Karajek Glacier, 4 miles wide, at 22 to 38 feet daily, and that of others at 24 and 46 feet daily, although he considered that the average motion of glaciers in Greenland was not over 21 feet.

As to the amount of deposition, Helland reported a great variation in Greenland in the amount of glacial mud carried down in suspension by glacial rivers, ranging from 2,374 grammes per cubic metre of water at Alandgardlek and 678 at Tuaparsuit, down to 104 at Jacobshavn. J. E. Marr (Geol. Mag., 1887) said that results in Greenland showed a variation from 200 grammes in one river to 9,744 in another.

Great glaciers still exist in British Columbia and Alaska, but are receding rapidly. The Muir Glacier in Alaska when seen by Vancouver in 1794 filled the inlet 25 miles farther down than it does now. I may say that Vancouver's statements and surveys were remarkably correct. The supposition that the recession of the glaciers in this area is comparatively recent is borne out by the fact that the surface disintegration as shown by excavations is practically *nil*. Also, we have some evidence of a rapid fall of the lake-level in old Indian kekwullie houses, which were pits roofed with logs and boughs and then covered with earth. At two points on Kamloops Lake similar huts exist about 70 feet above high water. They are always built as near to water as possible. One of these is at least two hundred yards above the level of the water. But about fifty years ago some were inhabited near the lake as low as 15 feet above high-water mark. There seem to be none between these two stages, suggesting a rapid fall in the water-level.

Regarding my estimate of 10,100 years, I may also note that Warren Upham allows 5,000 years for the erosion of glacial drift and 5,000 years for the Champlain period, which includes the period of retreat of the glaciers. My figures for this would be as above, 9,800. Professor Wright estimates 7,500 years for the streams tributary to Lake Erie to cut their valleys, a work which commenced after the retreat of the glaciers. Professor N. H. Winchell estimated 8,000 years for post-glacial erosion of the Mississippi gorge from Fort Snelling to St. Anthony Falls; G. K. Gilbert 7,000 years for the recession of Niagara Falls, which commenced soon after the close of the Glacial period. Against this must, however, be set the opinion of Dr. J. W. W. Spencer in his exhaustive report on the recession of the falls for the Geological Survey of Canada, in which he estimates 39,000 years as the period required, which he considers might be reduced 3,500 years by admitting Russell's theory of the Erie discharge. If the suggestion advanced by Dr. Pohlmann to the effect that the river re-excavated an old channel from the whirlpool to Queenston were correct this might be further reduced. The writer is not competent to judge as to this, but the retreat of the glacier from the high ranges of the Western Cordillera would probably be much later than in the east. It is generally admitted that the glacial stage of North America endured later than that of Europe.

REVIEWS.

I.—Submerged Forests. By Clement Reid, F.R.S. 8vo; pp. viii, 129, with 1 plate and 4 text-illustrations. Cambridge: at the University Press, 1913. Price 1*s*. net.

In this clearly and concisely written little book we are taught the lessons that can be learnt from a careful study of submerged forests by a geologist who is the chief authority on the natural history of the subject. The occurrence of peaty beds and of stumps of trees that had evidently grown on the area had been observed more than a century ago on the borders of estuaries and of other marshy tracts adjacent to the open sea, as in Lincolnshire. For the most part these exposures afforded no clue to the thickness and character of the strata that are now known to compose the submerged forests, and it is chiefly from the fine sections opened up in excavations for docks that the great interest and importance of these accumulations have been made manifest.

As the author points out, there is no doubt that some portions of marshy areas have subsided through compression and shrinkage of silty and peaty deposits. Again, in some instances alluvial areas that had been protected from the sea by higher portions of the mainland, as in north-western Norfolk, or by accumulations of beach or blown sand, as in the case of Eccles on the north-eastern coast of the county, have been brought within the influence of the sea by the erosion of the barriers or the shifting inland of the sand-dunes. The true submerged forests, however, are those which have undergone a considerable amount of depression, proved when the full thickness of the accumulations has been determined. Judging by the evidence of various excavations and borings, the term is rightly applied to nearly all the submerged forests observed along our coasts. Modern science requires that attention be bestowed not on the mass of the strata, but on each differing layer, so that the sequence of geological events, the fauna and flora, and the objects of archæological interest may be correctly recorded. The evidence supplied by dockyards and borings proves that some 50 or 60 feet of deposits may be grouped with the submerged forests, excluding the most recent marsh deposits and the uppermost estuarine silt or warp known as *Scrobicularia*-clay. Deeper down there are found alternations of peat or peaty soil with roots of trees, and estuarine silt, at three or four successive horizons, the whole often based on estuarine sand and gravel.

The author rightly refers to older deposits of somewhat similar character, such as the Cromer forest-bed of Pliocene age and certain Pleistocene deposits, as at Clacton, to which, however, the term 'submerged forests' is by common usage not applied. In dealing with the submerged forests he gives particulars only of the principal localities where careful detailed evidence has been obtained, as along the Thames Valley at Tilbury. There the channel was cut to a depth of about 60 feet below the modern river-bed, and the maximum elevation of the land is estimated to have been about 80 feet above its present level. Further north, along the eastern coasts, it is noted that in East Norfolk and in the Fenland the ascertained depth of the Alluvial strata with peat-beds is 50 or 60 feet, and in the Humber the channel was about 60 feet deep, as in the case of the Thames. It is remarked that "north of Flamborough Head it seems as though depression gave place to elevation, and when we pass into Scotland the Neolithic deposits seem to be raised beaches instead of submerged forests". Similar evidence is referred to in Scandinavia, Northern Ireland, and the Isle of Man.

Reference is made to the Pleistocene accumulations of the Dogger Bank and to the recent observations of Messrs. H. Whitehead and H. H. Goodchild, who obtained from the Bank loose masses of peat, known to the fishermen as 'moorlog'. Samples of this, examined by Mr. and Mrs. Reid, yielded a highly interesting series of plant-remains, and also of insects which were determined by Mr. G. C. Champion, all of species still living in Britain. The occurrence of this peat indicates a sunken land-surface or submerged forest at a depth below sea of about 60 feet or more. It is remarked that "the lowest submerged land-surface is found in Holland at just about the same depth as it occurs in England, and probably on the Dogger Bank also". Further, it is suggested that on this Bank the Pleistocene deposits may have "formed islands in the ancient fen, as they do now in East Anglia, Holderness, and Holland". It should be noted that the Pleistocene fossils of the Dogger Bank have been known for a longer period than "the last 50 years". In the Geological Magazine for 1878 (p. 443) a figure is given of the lower jaw of a mammoth dredged off the Dogger Bank in 1837.

The evidence of the submerged forests of Lancashire and the Bristol Channel again points to subsidence of about 60 feet, while data obtained in the excavations at the Celtic village of lake-dwellings at Glastonbury are mentioned as indicating that the movement of subsidence ceased "probably not more than 3,500 years ago".

Interesting particulars and conclusions are given respecting the English Channel and the submerged forests generally, in the south of England from Pegwell Bay to Cornwall. Some account is also given of the severance of Great Britain from the Continent. The areas were connected probably in Newer Pliocene times by a low divide, an extension of the Chalk of the North Downs. "Afterwards, during the Glacial epoch, when an ice-sheet accumulated and blocked the northern outlet of the North Sea, the water was ponded back in the southern part. There was no easy outlet northward for the water of the Rhine and other great rivers, so the level of the North Sea rose slightly till it overflowed this low col and cut an outlet where lies the present Strait of Dover." Subsequent elevation obliterated the Strait, and "converted a great part of the North Sea into a wide alluvial plain". When subsidence initiated the formation of the submerged forests the Strait again became an open channel, which has been gradually widened and deepened.

The author points out that much submarine erosion has taken place: that "tidal scour may go on at any depth, provided the current is confined to a narrow channel", and the Atlantic swell may remove coarse sand at depths of at least 50 fathoms. In the English Channel the troughs coincide with lines of tidal scour, and do not usually continue the lines of existing valleys, while the continental platform "is in all probability in the main a feature formed by the deposition of sediment during long ages".

In East Anglia the Norfolk Broads are regarded as directly associated with the subsidence connected with the submerged forests. In the south of England Romney Marsh and Pevensey Level are considered to be submerged flat-bottomed valleys that have been silted up. Westwards the marshlands bordering the rivers, as near Lewes, afford similar evidence, while Southampton Water, the Solent, and Spithead, with the adjacent harbours, are likewise submerged valleys. In Cornwall and on the Devon borders Plymouth Sound is held to represent a basin once filled with Tertiary and Secondary deposits and subsequently cleared out, the rocky basin having been in part silted up again. The stream-tin deposits belong to a late stage of the Pleistocene period, and were succeeded by the growth of trees and of sundry layers belonging to submerged forests. With regard to the vexed question of the isolation of St. Michael's Mount, the author is of opinion that "as far as can be calculated from its known rate of encroachment, the sea cannot have reached the Mount till long after the Roman period".

In a final chapter the author gives a summary of his conclusions, and points out that his main object has been to suggest directions for further research on a much-neglected subject. All the accumulations of the submerged forests appear to be of Neolithic age. The fauna and flora consist of living British species, with a few mammals since exterminated by man.

The account which we have given of this volume will indicate how carefully the author has considered all aspects of his subject with regard to both fact and opinion. At the same time it may be said that opinions which will be regarded by some geologists as debatable, are not wanting.

In a bibliography the author gives the titles of papers specially bearing on the matters discussed, but as he does not attempt to deal with or even enumerate the many submerged forests that have been described, there is no mention of some geologists like Pengelly, Ussher, and Codrington, who have published important papers on the subject.

II.—Geological Survey Memoir.

The Concealed Coal-field of Yorkshire and Nottinghamshire. By Walcot Gibson, D.Sc. 8vo; pp. vi, 122, with 3 plates and 5 text-illustrations. London: printed for His Majesty's Stationery Office, 1913. Price 1*s.* 6*d.*

THIS is an eminently practical memoir, dealing as it does with the underground extension of the Nottinghamshire, Derbyshire, and Yorkshire Coal-fields, sometimes grouped as the Great Yorkshire Coal-field. The exposed areas of Coal-measures in Nottingham border the Erewash valley in the western part of the county; in Derby they border the western side of that river-valley, extending through Chesterfield to the northern end of the county; thence in Yorkshire the strata are exposed from Sheffield to Leeds. The Magnesian Limestone and other Permian beds cover the eastern portion of the Coal-measures, succeeded by various members of the Trias and sundry superficial deposits. Beneath the Permian and newer deposits Coal-measures have been proved through the greater part of Nottinghamshire, and northwards into the area now known as the East Yorkshire Coal-field, which extends from Doncaster to Thorne and Selby in the Vale of York. This area is shown on the map (plate i), on which the sites of collieries and boreholes are marked, with the depth to Coal-measures, and other information. It comprises about 1,200 square miles, and the author remarks, in regard to the accessibility of the coals, that the boring at Kelham, near Newark-on-Trent, indicates that the lower seams of the Middle Coal-measures (a division which contains the chief workable seams), "are well within the 4,000-ft. limit of working in Nottinghamshire. In south Yorkshire, from the evidence of the Thorne Boring, it is reasonable to infer that they will seldom exceed this depth, while the Top Hard Coal in Nottinghamshire and Barnsley seam in Yorkshire should be met with under 3,000 feet."

After a general description of the Carboniferous strata, including particulars of the Coal-measures with its coal-seams and fossiliferous horizons, the author passes on to the Permian, Triassic, and superficial deposits, and gives a tabular statement of the thicknesses of these newer formations as proved in various borings from Owthorpe to Selby. A series of vertical sections (plate ii) also illustrates this subject. There is an important chapter on the configuration, structure, and limits of the coal-basin, and the map before mentioned will be found of great use in the study of this part of the subject. On it the contours of the concealed surface of the Coal-measures are indicated, and the approximate depth to these strata, over areas not yet proved, can be ascertained. Diagrammatic sections are also inserted in the text to explain the probable structure of the coal-field.

Detailed records of shafts and borings are given, together with a series of vertical sections (plate iii) to illustrate the Middle Coal-measures above the Top Hard or Barnsley Coal.

The volume thus contains a full account of all that is known of this great and important tract of concealed Coal-measures, the details being tabulated and the problems discussed by one who is a leading authority on the subject.

III.—Hampstead Heath: its Geology and Natural History. Prepared under the auspices of the Hampstead Scientific Society. 8vo; pp. 328, with coloured frontispiece, 10 other plates, and 3 maps. London: T. Fisher Unwin, 1913. Price 10*s*. 6*d*. net.

THIS volume, printed in bold and excellent type on thick but light paper, will justly take a high place among local natural histories, and, as the several contributors show, "Hampstead still offers, considering its nearness to London, considerable scope for the study of nature." This especially applies to the protected area of the Ken Wood Estate.

Of the three maps, one shows the contours of the land, without names of places. Affixed in front of it is a geological sketch-map on transparent paper, showing somewhat roughly the names of principal localities, and the areas occupied by London Clay, Bagshot Sand, Plateau Gravel, Boulder-clay, and Valley Drift. In this map is marked the area under description, which is confined to a radius of 3 miles from the Hampstead Flagstaff. The third map shows the northern portion of Hampstead and part of Finchley, but does not extend over the 3 mile limit.

The section on geology occupies twenty-eight pages, and when we mention that it is written by Mr. F. W. Rudler it is needless to add that it is an admirable essay. An account is given of all the formations above mentioned, including even the 'Claygate Beds', a term recently applied to the passage-beds of sand and loam that bridge over the interval between the mass of stiff London Clay and the mass of overlying Bagshot Sands. Two photographic views are given of the Sands in Ken Wood. The fossils of the London Clay rightly receive a good deal of attention, and a new list is given of species collected from the Hampstead Tube Railway. The minerals of the formations are duly noted, while the subjects of soils, scenery, water-supply, and deep borings are not neglected; nor, we may add, are references to the former resident geologists, N. T. Wetherell and Caleb Evans, and to others who have dealt with the geology of the district.

The section on topography is by Messrs. H. R. Maynard and C. J. B. Findon, while one of the three botanical chapters, that on the vegetation of Hampstead Heath and the neighbouring woods, by Mr. A. G. Tansley, contains references to the soils and substrata, the author observing that "it is essential to understand the geological structure of a district in any attempt to unravel the distribution of the vegetation". In other chapters there are records and descriptions of various forms of animal life, also of pond life in particular, and of climate.

IV.—A Manual of Petrology. By F. P. Mennell, F.G.S., etc. 8vo; pp. 256, with 124 figures in the text. London: Chapman and Hall, Limited. Price 7*s.* 6*d.* net.

THIS book forms an enlarged and improved edition of the author's *Introduction to Petrology*, which was published in 1909. The text has been printed in larger type, and over fifty of the figures, mostly photomicrographs, are new and are a great improvement on those which appeared in the book in its earlier form. The chapters have been re-arranged in more logical sequence, several of them have been rewritten, and tables of analyses have been inserted.

The first three chapters deal with the general and optical properties of rock-forming minerals. Due emphasis is laid on the value of interference figures as aids to the determination of minerals in thin sections. For purposes of description the minerals are classified according to their chemical compositions, instead of by their optical properties. Had they been arranged according to the latter this part of the book would have been more immediately useful in determinative work. The insertion of the actual values of the birefringence for the doubly refracting minerals would have been a great improvement. The simplification of the chemical formulæ for one or two of the minerals has been carried too far. Thus topaz is given as $Al_2O_3 . SiO_2$, thereby failing to show the importance of the hydroxyl and fluorine in its constitution.

The descriptions of the igneous rocks occupy four chapters and though necessarily short they are very much to the point. The nomenclature has been reduced to the simplest form. The rocks are classified according to their acidity and mode of formation, whereby nineteen divisions are obtained, and the names of these divisions, with suitable prefixes, are made to suffice. The book is written to meet the needs not so much of students as of working geologists, and for such simplicity of nomenclature is a great advantage. Nevertheless, it is very difficult to place many important types in so simple a scheme; thus, borolanite and kentallenite are found under the dolerites, while such well-known groups as the essexites and monzonites do not appear.

There are short chapters on the sedimentary rocks, weathering, the chemistry of rocks, radio-activity, and lastly a useful chapter on the collection of material and the preparation of thin sections.

Chapter ix on the origin and variation of igneous rocks is full of interest, as it contains the author's ideas resulting from a large amount of field work, and in it he states a very strong case for the origin of igneous rocks from 'refusion'. The chapters on the metamorphic rocks also contain much original matter and discussions of many controversial questions.

Throughout the book a great many of the rocks taken as examples are from South African and Australian occurrences, so that the book will doubtless be found most useful by geologists working in those parts of the empire.

V.—The Age of the Earth. By Arthur Holmes. 8vo; pp. xii + 195, with 4 plates, 5 text-figures, and 5 diagrams. London and New York: Harper & Brothers, 1913. Price: cloth, 2*s.* 6*d.* net; leather, 3*s.* 6*d.* net.

THE problem of the age of the earth has occupied the attention of scientists repeatedly since the fourteenth century, and has been a frequent source of keen controversy. This little book has for its aim the criticism, in the light of recent work, of the various methods which have been applied to the solution of the problem. After a brief historical account the several methods are treated in detail.

Kelvin's estimate, based on the effect of tidal retardation on the shape of the earth, is passed over as being based on astronomical theories not generally accepted.

As instances of attempts to connect sedimentation with astronomical data, the work of Croll and of De Geer on the date of the culmination of the Glacial period is quoted. In the same chapter is a review of Gilbert's attempt to connect the regular alternations of limestone and shale in the Upper Cretaceous of Colorado with the position of perihelion.

The work of denudation is considered in the light of the available data for several large rivers, and of Dr. F. W. Clarke's recent estimates of solvent denudation. It is estimated that 9,000 million tons of material are deposited annually on the continental shelves.

The time-worn method of determining the age of the oceans from measurements of the ratio of accumulated sodium to the annual increment is discussed in detail. By introducing numerous corrections it is possible to arrive at ages varying from 80 to 340 million years, and, as all the corrections are based on insufficient data, it is shown that the method is extremely unreliable.

In the chapter on the relation of sedimentation to geological time the previous estimates based on the thickness of sediments are tabulated. Of these the three most recent, those of Geikie, Joly, and Sollas, vary between 80 and 100 million years. The author points out four further methods by which one arrives at ages varying from 250 to 350 million years, with a possible upper limit of 700 million. It is held that we may be living in an age of more than average sedimentation, in support of which opinion a communication from Professor Chamberlain is quoted.

The author has no confidence in purely geological methods for determining the earth's age. He is, however, enthusiastic on the possibilities brought to light by the study of radio-activity in the rocks, a subject on which he has done much original work.

The accounts of recent research on radio-activity, of the disintegration theory, and of the measurement of radio-activity in rocks, are well written. The work of Joly and Fletcher on pleochroic haloes is reviewed, and it is pointed out that these haloes, after further study, may be used as an indication of the ages of the minerals in which they occur.

The chapter on radio-active minerals is a very important one, giving a lucid account of the refined methods of estimating the age of rocks by determining the ratio of helium to uranium, or of lead to uranium, in the radio-active uranium minerals. The work of Strutt, Boltwood, and Rutherford is described, and the author has also given us the results of some of his own experiments. For Archæan rocks measurements of the 'helium ratio' give an age of 700 million years; measurements of the 'lead ratio', however, give double that figure.

In the last chapter the author reviews all the evidence, and endeavours to show in what directions one must look for a reconciliation between the new and the older methods of determining the age of the earth.

There are two useful appendices, one giving various data referred to in the chapters on radio-activity, the other giving a very complete bibliography of the whole scope of the book.

In the small space at his disposal the author has handled a vast subject in a very able manner.

VI.—Yorkshire Type Ammonites. Edited by S. S. Buckman. The original descriptions reprinted and illustrated by figures of the types reproduced from photographs mainly by J. W. Tutcher. Part ix, 10 plates, with descriptions. London: Wesley, 1913.

With this part begins vol. ii of this exceedingly important work. It was long recognized that until some master hand had examined, redescribed, and figured the numerous species of Lias Ammonites from Yorkshire that had been named by Martin Simpson little progress could be made in this fauna. Mr. Buckman essayed the task, and every species that he deals with clears up ground of a most uncertain and treacherous nature. And now that he is well into the work, it is for palæontologists to see that he is enabled to complete it.

Mr. Buckman's procedure is to print the original diagnosis, to give additional details, and then to discuss and amplify them, recording his result in a final paragraph fixing the nomenclature. Such work is of the highest possible value, for until we have cleared up and fixed old types it is merely beating the air to describe new ones.

We are glad to see that the author tabulates and explains once more his terminology and his zones, as that renders his position and work quite clear and comprehensive.

For Mr. Tutcher's photographs we have nothing but praise. With a critical knowledge of the forms and their details, he has mastered his art, and the combined efforts of the two friends has laid all students of the Ammonites under a great debt. More subscribers are, however, needed to push the work forward to a more rapid completion.

VII.—Brief Notices.

1. Yorkshire Philosophical Society.—The Annual Report of this Society for 1912 contains a notice of the building of a new lecture theatre, erected by the influence of the President, Dr. Tempest Anderson, and formally opened by Professor T. G. Bonney, F.R.S., who delivered a discourse on the "Development of Education".

2. Cambridge Philosophical Society.—To the Proceedings of this Society (vol. xvii, 1913) Mr. R. H. Rastall has contributed notes on "The Mineral Composition of some Cambridgeshire Sands and Gravels", including Plateau and River Gravels and wind-drifted surface-deposits. While the most abundant material in all the sands is naturally quartz, it is interesting to find that "next in abundance is flint in white opaque grains, often well rounded". Other minerals are glauconite, tourmaline, kyanite, staurolite, garnet, hornblende, augite, hypersthene, and epidote, while there is an almost complete absence of muscovite. The author concludes that "the materials have been derived from two sources, partly from the Neocomian sands of Cambridgeshire and the neighbourhood of the Wash, and partly from far-distant sources by ice-transit, that is, from the solid matter transported on and in the ice from Norway, Scotland, and the north of England". In another paper on "The Minerals of some Sands and Gravels near Newmarket" the most notable heavy minerals recorded are zircon and rutile, while kyanite, staurolite, and tourmaline are rare or absent. Moreover, in certain beds of loam and marl muscovite proved to be abundant.

3. South African Vertebrata.—In the ***Annals of the South African Museum*** (vol. vii, 1912) Dr. R. Broom describes a new species of ***Propappus***, and expresses his opinion that this genus and the allied ***Pareiasaurus*** "were heavily built animals which probably walked with slow, deliberate movements, such as we see in the large tortoises. They were land animals, and it seems more likely that they lived even on the dry land than that they frequented the marshes. The structure of the claws and the humerus would seem to indicate that they were digging animals, and probably, like the ***Echidna***, they

defended themselves from their carnivorous enemies by digging into the ground".

In a second paper Dr. Broom describes a species of *Tylosaurus* (a Pythonomorph) from the Upper Cretaceous beds of Pondoland; in a third paper he gives an account of a new type of Cynodont from the Stormberg named *Tritheledon riconoi*, while the new family is called the Tritheledontidæ; and in a fourth paper he discusses some points in the Dicynodont skull.

4. Pleistocene Geology of New York State.—This formed the subject of the annual address to the Geological Society of America, Mr. Herman L. Fairchild, President (Bull. Geol. Soc. Am., xxiv, 1913). The author discusses the limits, thickness, movement, and recession of the ice, its erosional and constructional work together with that of glacial waters in connexion with drumlins, moraines, eskers (sub-glacial), kames (extra-glacial), and other features. In conclusion he refers to Glacial time, remarking that "the estimates of those best qualified to judge of the length of Pleistocene time are from 500,000 to 1,500,000 years".

5. North American Camels.—After six years excavation at La Brea, California, the University of California has been so fortunate as to obtain several nearly perfect skulls of *Camelops hesternus*, and varieties with associated skeletal material representing the greater part of the animal. This has enabled Dr. Merriam to revise all previous work on the group and speak with more certainty as to the many species raised on imperfect material. (Univ. Calif. Publ., Bull. Dept. Geol., vii (14), pp. 305–23, May, 1913.)

6. The Manus of *Trachodon*.—A well-preserved skeleton of *Trachodon marginatus*, Lambe, from the Edmonton formation of the Red Deer River, Alberta, Canada, has allowed Mr. L. M. Lambe to describe the manus in detail. This differs materially from the description given by Barnum Brown of the manus of a specimen from the Lance formation of Wyoming in 1912. That species was called *T. annectens*. About four feet of the tuberculated skin is preserved in the new specimen. Mr. Lambe gives a full account of the manus and three plates in the *Ottawa Naturalist*, May, 1913.

7. Road-metal.—The following paragraph is reprinted from reports for the year 1912, on the Geological Survey, the Geological Museum in Jermyn Street, etc. (P.P., Cd. 6793), 1913: What is essentially a new departure in the work of the Geological Survey of Scotland was made in 1912. The Argyllshire County Council, recognizing the importance of utilizing to the best advantage the great variety of stones suitable for road-metal in that county, desired to purchase a series of road-stone maps showing the occurrence of road-stones in places easily accessible from the main roads. Maps were prepared on the scale of six inches to one mile, on which were marked only the outcrops likely to be of importance for this purpose. The surveyors find them of great use, as the published one-inch maps are on too small a scale to show all the smaller intrusions of igneous rock, some of which make excellent road-stones. As they are not complete maps they are comparatively inexpensive to prepare.

CORRESPONDENCE.

THE DIVISION OF THE UPPER CHALK.

Sir,—Mr. Jukes-Browne's article under this heading in the April number divides itself naturally into two parts, one dealing with the personal aspect, the other (not altogether impersonally) with the scientific aspect.

As for the personal aspect, the position is as follows: Certain observations as to faunal changes within the old zone of *A. quadratus* were judged at the time of the publication of "The Zones of the Chalk in Hants" not to amount to evidence of zonal breaks; they were therefore treated as indicating the existence of subzonal breaks, whose exact position and nature were then not yet ascertained. A large body of further observations enabled me to define the exact position and nature of these breaks and showed that one of them was of zonal importance, involving the proposal of a new zone. Mr. Jukes-Browne announced this intended proposal of mine in such a form that the natural inference was that it was a mere reshuffling of the data already published—the last thing I desired, and forced upon me by some one else's unauthorized version of my unpublished work.

As for the scientific aspect, some of the points originally raised (or which could be raised on his reply) are not of sufficient general interest to justify further elaboration. Of the broader points, what was expressly stated to be a fact concerning the Yorkshire cliffs is now admitted to be an assumption; and the tabulation of records from the old zone of *A. quadratus* in Sussex under the new zone of *O. pilula*, a representation of fact, is now admitted to be based on an assumption which happens to be false, there being at least 100 feet of the restricted zone of *A. quadratus* exposed in the Sussex cliffs. Surely it is not very "captious" to object to these assumptions being presented as established facts. Mr. Jukes-Browne was *not* told by me that he "had no right" to make the assumption as to Yorkshire. He is entitled to make any assumption; his grounds for making it are then a legitimate subject of criticism.

Several broad points seem to go by default, e.g. that the highest Yorkshire chalk is so far North-German in its apparent affinities that its nomenclature should be North-German rather than Anglo-Parisian, and its fossils should not be mixed up with those of the Anglo-Parisian chalk of Sussex; or again, that records from Yorkshire, where no chalk of the restricted zone of *A. quadratus* is admitted to be preserved, cannot logically be used to prove the absence of certain species in that epoch. If this were logical it could be proved that in Kent all the common fossils of the Chalk died out in the zone of *Marsupites*.

Mr. Jukes-Browne now writes of a "Yorkshire zone of *A. granulatus*", a zone quite novel to me. It would be interesting to know where to find a definition of this zone and how it is distinguished from the zone of *O. pilula* or *Scaphites binodosus*, or again, from Dr. Rowe's "local zone of *Inoceramus lingua*".

Mr. Jukes-Browne's challenge to me to prove that *A. granulatus* does occur in the restricted zone of *A. quadratus* is really irrelevant.

I have not stated that *A. granulatus* does occur there, and if I could not point to an undoubted *A. granulatus* from a horizon at which any Belemnites are most exceptional occurrences it would not prove that *A. granulatus* never occurs there, as assumed by Mr. Jukes-Browne. It so happens that the challenge can be met out of his own mouth. He says: "With respect to Sussex I relied on the published records, according to which . . . in the cliffs between Seaford and Brighton . . . *A. granulatus* occurred through at least the lower 150 feet." As the zone of *O. pilula* is only from 100 to 110 feet thick in the Sussex cliffs (and does not exceed 105 feet at Seaford), *A. granulatus* at 150 feet must be well up in the restricted zone of *A. quadratus*. Specimens of *A. granulatus* occurring at 120 feet would be equally, though less deeply, in the restricted zone of *A. quadratus*.

R. M. Brydone.

27 Twyford Mansions, W.

THE LEICESTERSHIRE AND SOUTH DERBYSHIRE COAL-FIELD.

Sir,—I shall be much obliged if any readers of the Geological Magazine can inform me of the whereabouts of a collection of Coal-measure fossils, chiefly plants, made by Edward Mammatt, author of *Geological Facts*. He was the first man, as a pupil of William Smith, to put into practice for Carboniferous zonal work the principle that strata are characterized by their organic remains. A detailed coloured section is given in his work, with the position of fossils found indicated. Moreover, these fossils are figured in his work, but unfortunately in the state of lithography at that time accuracy was not possible, and it would be necessary to examine the originals in many cases to be sure what fossil is intended. So valuable is this record, since the sections are now bricked in, that the information the fossils could afford would be of the greatest assistance to me in further working out the palæontology of this coal-field. Mammatt was a friend of the late Professor A. H. Green, who surveyed part of the district, afterwards going to Oxford.

Inquiries were made amongst several colleagues when my preliminary account of this coal-field was communicated to the Survey memoir on this coal-field, published in 1907, but I was then unable to obtain any information. Since I am hoping to revise this account, which was drawn up before the work had gone very far, and as I have a good deal of additional information, any facts of importance that may be known to readers of this Magazine will be cordially welcomed.

When the above-mentioned account was written, reliance had to be placed upon certain data which may, after a fuller study of the question, have to be read in a new light, in spite of the fact that my friend the late Mr. Fox-Strangways and I were satisfied with them at the time. It is in this connexion that Mammatt's sections are specially interesting.—Yours truly,

A. R. Horwood.

Leicester Museum.
July 9, 1913.

OBITUARY.

SIR JONATHAN HUTCHINSON, KT., F.R.C.S., M.D., LL.D., F.R.S.

BORN JULY 23, 1828. DIED JUNE, 1913.

IN Sir Jonathan Hutchinson there has just passed away in his 85th year an eminent physician, a Fellow and (in 1889 and 1890) Hunterian Professor of the Royal College of Surgeons, most distinguished as a specialist in diseases of the skin; elected a Fellow of the Royal Society (1882); one of the most kindly and unselfish of men, ever ready to do good to others. Outside the medical profession —to which he devoted a long and laborious life, and spent much money and time in advancing—his pet idea was that the establishment of small local museums, scattered about the country, would be of the greatest value as aids to education. He himself established and supported two such, one at Selby in Yorkshire (his birthplace) and the other at Haslemere, at which latter place was his home,[1] and where he retired after a long and strenuous career as a medical man.

Although intensely interested in geology, he could from his well-stored mind address an audience on a great variety of subjects, and was never so happy as when lecturing to a roomful of country people or to young folks. The pleasure of imparting information to others was only equalled by the eagerness with which he sought and acquired knowledge. History, poetry, archæology, botany, and geology all in turn attracted his attention and were studied with care. Even when 73 years of age, he travelled thousands of miles in India and Cape Colony in pursuit of his investigation into the cause and origin of leprosy, eager to help to relieve the sufferers and, if possible, to cure them. Like his colleague Sir Joseph Lister (both members of the Society of Friends), Jonathan Hutchinson leaves behind him the record of a life devoted to the welfare of his fellow-men and the relief of human suffering.

DR. P. LUTLEY SCLATER, M.A., F.R.S.

BORN NOVEMBER 4, 1829. DIED JUNE 27, 1913.

WE much regret to record the death of Philip Lutley Sclater, M.A., D.Sc., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., Hon. Fellow of Corpus Christi College, Oxford, at his country seat, Odiham Priory, Winchfield, Hampshire, at the advanced age of 84. He was the second son of William Lutley Sclater (his elder brother being the Right Hon. G. Sclater-Booth, afterwards Lord Basing). He was educated at Twyford and Winchester, where he obtained a scholarship at Corpus, and took his degree and a first in mathematics at Oxford in 1849, remaining there two years afterwards. Later Dr. Sclater entered Lincoln's Inn, and was called to the Bar in 1855. Under the influence of Strickland he took up ornithology, and spent some years in travelling in Italy, Sicily, Canada, and the United States. Later on he visited Morocco, Egypt, South Africa, and the West Indies.

[1] The Library, Inval, Haslemere.

He was one of the founders of the British Ornithologists' Union, and was editor of the *Ibis* for over fifty years. He contributed several bird-catalogues to the British Museum, and was recognized as one of the leaders of systematic zoology. He became a Fellow of the Zoological Society in 1850 and was elected Secretary in 1859, which office he held until 1902 (a period of forty-three years), when he retired on a pension. He was deeply interested in the scientific side of zoology, and largely promoted the publication of the *Zoological Record* (founded in 1864), which he induced the Zoological Society to aid by an annual grant and to be wholly responsible for from 1866 to nearly the present time.

Dr. Sclater was also keenly interested in promoting the carrying on of the *Index Generum et Specierum Animalium*, by Mr. Charles Davies Sherborn, F.G.S., F.Z.S., which was commenced by the author in July, 1890, and is *still in progress*—a stupendous undertaking to be carried out by the labour of one man. At the date of the first notice (Proc. Zool. Soc., 1896, p. 610) 130,000 slips had already been stored away in alphabetical order (see GEOL. MAG., 1896, pp. 557–61). The first volume of this famous work, which occupied eight years in its production, was issued in 1902 by the Cambridge University Press, and embraced all names from January 1, 1758, to December, 1800, and contains 61,600 entries. The work, under the support of a committee, has been continued, and each year its author has issued a report of progress. The slips are stored in the Natural History Museum, where they are always accessible to all workers in zoology.

As regards the continuation of this important undertaking, Dr. Sclater had the pleasing satisfaction to know in April of last year (1912) that the Trustees of the British Museum had resolved to take over the work of the compilation of the *Index Animalium*, and had given Mr. Sherborn rank as a "Special Assistant" on the staff of the British Museum (Natural History).

One who knew Philip Lutley Sclater well writes: "The death of Dr. Sclater deprives many of a real friend, and science in general of a warm supporter. A zoologist primarily, he yet found time to take an interest in geology, and was ever ready to learn what geology had to teach in the elucidation of questions of geographical distribution and evolution. As Secretary to the Zoological Society he had often led parties of geologists around the Gardens."

We cannot conclude this brief notice of Dr. Sclater's valuable services to science without a passing reference to his important contribution to the study of the geographical distribution of animals.

In 1858[1] he discussed the primary zoological divisions of the earth, taking birds as the basis, and designated six great regions, which he named the Palæarctic, Æthiopian, Indian, Australian, Nearctic, and Neotropical. Although the general tendency at present is to unite several of these regions together, they nevertheless have proved of great service to palæozoologists in dealing with the broad questions of geographical distribution of animals in the past, and it is interesting to find how far Dr. Sclater's studies in zoology had advanced our

[1] Journ. Proc. Linn. Soc. (Zoology), vol. ii, pp. 130–45 (1858).

knowledge more than fifty years ago, even before Wallace and Darwin had entered the field.

Dr. Sclater's eldest son, Mr. W. L. Sclater, M.A., like his father, is distinguished as a systematic zoologist.

JAMES LOGAN LOBLEY, F.G.S.

BORN 1833. DIED JUNE 27, 1913.

BY the death of J. Logan Lobley the Geologists' Association of London have lost one of their earliest friends. In 1865 he became a member of the Association and a Fellow of the Geological Society, but most of his attention was bestowed on the younger body, of which he was Honorary Secretary and Editor 1871–3, Editor alone till 1881, and Treasurer 1881–5. Deeply interested in the field-work of the Association he conducted many excursions, and those to the Weald of Kent, in 1879 and 1882, will long be remembered by many who took part in them. Lobley's chief written work was his *Mount Vesuvius*, 1868, expanded from a pamphlet to a volume in 1889. He also wrote a separate volume on *Hampstead Hill* in 1889, and contributed a score of papers on various subjects to the GEOLOGICAL MAGAZINE and other serials.

From a position of comparative affluence fortune had laid him low, and his later years had been sad ones, in which he had eked out a poor living by coaching explorers and others in his favourite science. But he worked on to the last and passed away at the age of 80, at 36 Palace Street, S.W., just a few days before the announcement that the Government had awarded him a Civil List Pension of £60, of which he had already drawn a very welcome instalment, lightening the trouble of his last few months.

He was buried at Hampstead Cemetery on July 1, attended by Dr. W. S. Bruce, the Antarctic explorer, and a few other devoted friends from the Geological Society and the Geologists' Association.

MISCELLANEOUS.

WE learn from *Nature* (May 29, 1913) that a "new iron Bacterium" has been described by Mr. E. M. Mumford in the Transactions of the Chemical Society. It was discovered in the Bridgewater Canal tunnels at Wasley, Lancashire, where the water contains much iron derived from colliery pump-water. The new bacterium appears to have a twofold action, an aërobic action whereby it precipitates ferric hydroxide from iron solutions, and an anaërobic action which transforms the ferric hydroxide into bog iron ore with partial reduction of the iron to a ferrous state.

RETIREMENT OF PROFESSOR C. LAPWORTH, F.R.S.—We learn that Professor W. S. Boulton, B.Sc., F.G.S., Assoc. R.C.S., Professor of Geology at University College, Cardiff, has been appointed to succeed Professor C. Lapworth, F.R.S., who is retiring at the close of the present session. Before his appointment to University College, Cardiff, Professor Boulton had been assistant lecturer in geology at Mason College under Professor Lapworth (*Nature*, June 12, 1913).

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ORIGINAL ARTICLES.

I.—The Origin of Mountains.

By Colonel S. G. Burrard, C.S.I., R.E., F.R.S., Surveyor-General of India.

1. The reply by the Rev. O. Fisher (Geological Magazine, June, 1913, p. 250) to Sir Thomas Holland's note leads me to ask permission to place the geodetic case before your geological readers. I ask geologists to give a hearing to a geodetic computer.

No living man has done more to encourage geodesists and to create a geological interest in their work than Osmond Fisher; no man has done so much to impress upon geologists that they cannot afford to ignore geodetic results as he has; no other man has had the advantage of being able to speak with authority both as a mathematician and as a geologist. We recognize the weight of his opinion. May I explain why we have the presumption to differ from some of his conclusions?

2. Mr. Fisher has explained the origin of mountain ranges by what is known as the 'floating crust hypothesis', in which he assumes a solid crust floating upon a liquid substratum. He accepts the principle of isostasy in its entirety, and holds that mountain ranges are supported, not by the rigidity of the earth, but by floatation like icebergs.

Geodetic computers find three objections to Mr. Fisher's hypothesis: Firstly, we think that no hypothesis can be accepted now that is dependent upon the assumption of a liquid interior to the earth, and in this point we are in agreement with Sir Thomas Holland. Secondly, Fisher's hypothesis is not generally applicable to all continents and to all mountains, but has to be 'amplified' or 'modified' when any particular topographical feature comes under analysis. Thirdly, Fisher assumes that the depth of compensation of a mountain is directly proportional to its height above sea-level; this assumption is opposed to the results of geodetic observations.

3. Mr. Fisher has argued that the rotation of the earth will give to the liquid interior an effective rigidity; but this rotation has conferred no rigidity upon our oceans, and even if it did render the liquid interior rigid, it would only do so in low latitudes where the rotation velocity is high. I understand, moreover, that the earth's interior was assumed by Mr. Fisher to be liquid, in order to explain the floatation of the crust. If the liquid is now proved to be rigid, the crust cannot be floating upon it.

4. I said above that Mr. Fisher's theory is not generally applicable: may I explain what I mean? If he would define his theory in

general terms, such as the following—"Every topographical feature standing above sea-level is compensated by an underlying deficiency of density, and that deficiency is uniform to a depth equal to ten times the height of the feature"—the geodetic computer could grapple with the problem. It is true that the basis of the Fisher theory is that each mountain has an attenuated root, and the depth of this root is always equal approximately to ten times the height of the mountain above it; but when computers come to apply this theory to actual topographical features they are met everywhere with local exceptions. In Northern India alone we have three such local exceptions: (1) The compensation of the Himalayas is said by Mr. Fisher to exist not only under the mountains themselves but to extend laterally beyond the Himalayan region. How can computers test a theory when the limits and size of the roots are not exactly defined? (2) According to Mr. Fisher's general proposition mountains have roots and valleys have none. But the Ganges valley is an exception; here the alluvial deposits are said to have been so heavy as to press downwards into the liquid substratum. It has thus a root of deficient density, just as if it were a mountain. How can computers deal with a valley that is not in accord with the general theory? If one valley is taken to be an exception to the general theory, how many others are to be treated as exceptions? (3) An advocate of the Fisher theory, writing in *Nature*, May 8, 1913, discusses the Himalayas and their isostatic compensation. He then dismisses the Vindhya Mountains and their compensation as though they presented a different problem to be treated differently. But geodetic computers cannot alter their formulæ to suit every geological peculiarity; they must be given a general theory which is applicable to the Himalayas, Vindhyas, Alps, and other ranges. They cannot compute Himalayan effects alone, and subsequently examine Vindhyan effects alone, for the two are interdependent. Computers have to regard Asia as a whole, and deal with it as such.

5. Two theories of mountain compensation have been placed before geodesists—Mr. Hayford's and Mr. Fisher's. According to the former the depth of compensation is everywhere the same, namely 70 miles, but the degree of compensation is larger for high mountains than for low. According to Mr. Fisher's theory the degree of compensation is always the same, but the depth to which that compensation extends is greater for high mountains than for low. Mr. Hayford varies the amount of compensation by altering its degree; Mr. Fisher varies it by altering its depth.

Now if we test these two theories as stated above by the geodetic results of America and India we find Hayford's strongly supported and Fisher's contradicted. Hayford's theory assumes constancy of depth, and this assumption we find borne out. Fisher's assumes a greater depth of compensation for high mountains than for low, and this we do not find borne out. Hayford's theory is applicable to a solid globe; Fisher's is not. Hayford's has explained both the large negative values of g that have been always found by observation to exist in the interiors of continents, and also the large positive values of g that have been met with on islands and coasts. Fisher's theory does not explain these anomalies.[1]

6. Although Mr. Hayford has shown that continents and mountains are generally compensated, yet we have no grounds for assuming that mountains maintain a constant height. The author of the theory of isostasy said that it was not intended to account for the origin of mountains, and that it was only put forward to explain how existing mountains were maintained. It has even been argued by others that as material is removed from peaks and crests by denudation the mountains become lighter and in consequence higher. This seems to me to be an unwarranted assumption based on no data whatever. In a similar way it has been stated that the rock floors of river valleys continue to sink as silt is deposited upon them, the underlying idea being that the weight of every additional layer of silt deposited is too much for the solid crust to support, and that the latter yields in consequence. Deep boreholes have been sunk in the deltas of certain rivers, and bones, shells, and remains of plants have been found at all levels, however deep the boreholes have been taken; the conclusion has been drawn that these remains were originally deposited at sea-level.

But let us consider the case of the Plains of Northern India. These extensive plains are deposits of silt brought down by rivers from the Himalayas. Boreholes have been sunk and remains of organic life found buried at great depths in the silt, but these observations do not justify the assumption that the rock-floors underlying the Indus-Ganges Valleys have been continually sinking under the increasing weight of the deposits. Both on the west and on the east long, deep, narrow, submarine troughs extend out into the oceans in continuation of the Indus and Ganges Valleys. The waters of the Indus and Ganges are continually pouring silt into these deep troughs; amongst the silt are remains of organic life that once flourished at sea-level—plants, shells, bones—and these are being deposited at great depths in the troughs. With this going on before our eyes how can we presume to argue that the remains found at great depths in boreholes were originally deposited at sea-level? The simplest explanation is that the plains of Northern India are concealing a sub-crustal crack, that the submarine troughs are continuations of this crack, and that as the crack has opened and grown deeper the deposits filling it up have been continually sinking to lower levels.

7. The problem of isostasy that is now requiring solution may be stated as follows: "Continents and mountains have been found to be compensated by underlying deficiencies of density; how has this condition resembling hydrostatic equilibrium arisen upon a solid

[1] Although Hayford's theory is the nearest approach to truth that has yet been made, it does not afford a complete explanation of every observed anomaly. In my paper on the origin of the Himalayas I corrected all geodetic results in accordance with the Hayfordian system, and I then regarded the uneliminated residuals as indications of actual departures from isostasy. Mr. Fisher calls attention to a change in the observed value of g at Dehra Dun that has taken place between 1870 and 1904. This change is, however, apparent only; it is due to the recent introduction of a correction for the vibration of the brick pillar upon which the pendulum is swung.

globe of rock?" The cores of continents and mountains are found generally to consist of crystalline igneous rocks, and the simplest explanation of isostasy seems to be that these crystalline igneous rocks have arisen from below by vertical expansion. I beg to suggest that if great cracks occur at depths of miles in the sub-crust the rocks may be so disturbed by lateral pressure as to undergo chemical change, and to expand vertically. Mr. Fisher argues that lateral pressure should lead to increase of density. If rock be subjected to compression from all sides its density would increase, but if the pressure is from one side only, and the rock is able to escape vertically, an increase of density may not ensue.

8. Mr. Fisher states that any *deep* rift in our globe must at once be filled by heavy intrusive molten rock rising from below. He cannot accept the view that the solid globe may be cracking, and that the cracks are being filled by material from *above*. But is the intrusion of molten rock from below dependent at all upon depth? Such intrusions are to be seen at high continental altitudes, whilst the great oceanic deeps remain unfilled by them.

It is, I think, conceivable that the outer shells of a solid planet might become cracked in all directions, and that if the planet were devoid of atmosphere and oceans, as Mars possibly is, the cracks on its surface might be visible. If the outer shells of a solid globe were cracking, a condition resembling hydrostatic equilibrium might be produced. As a crack was opening the lateral pressure would suffice to increase the elevation of ridges along its edges, and when the opening force declined the weight of the elevated ridges would tend to close the crack. There would thus be a resilience that would lead to oscillations of level.

9. Suess has suggested that the Himalaya Mountains are advancing southwards, and that the Japanese Islands are moving outwards towards the Pacific Ocean. The geodetic observations in India lead me, however, to believe that the Himalaya Mountains are being forced northwards by the opening of the Indus-Ganges crack, and that the Japanese Islands are being pressed backwards against the continent of Asia by the opening of the Tuscarora Deep. I think that the elevation of the Japanese Islands and their movement westwards as the Tuscarora Deep opens, may possibly teach us how continents and mountains originate and grow.

II.—The Beaufort Beds of the Karroo System of South Africa.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in University College, London.

THE great Karroo System of South Africa was divided by its discoverer, Andrew Geddes Bain, into four formations on lithological characters. They are—

The Stormberg Series.
The Beaufort Beds.
The Ecca Beds.
The Dwyka Series.

It has long been recognized that the Dwyka conglomerate, which forms a large part of the lowest series, is of glacial origin, and the common occurrence of smoothed and striated pavements below it all along its northern exposure seems to show that it is the product of a great continental ice-sheet.

It is my purpose in the present paper to discuss the mode of origin of the Beaufort Beds. These beds, which have long been famous for the wonderful reptilian fauna which they contain, form the greater part of the Karroo and Orange Free State.

The whole series has a thickness of roughly 9,000 feet, the great bulk of which is composed of mudstones. These rocks are usually of very fine grain and, as a rule, are not bedded; they often show banding, a difference of colour and texture, but are very seldom bedded; that is to say, it is usually impossible to expose a flat level surface of them, for they break into small cubical pieces so as to leave a quite irregular face. They are broken up by sandstones, usually impersistent, and usually also of very fine grain. In the middle of the series, on Great Winterberg, and also, so Dr. Broom informs me, on the Compass Berg, is a much more powerful development of sandstones of a massive kind and generally of coarser grain.

The colour of the lower beds is usually dark grey or olive, the sandstones being of the same colour on fresh fractures, although they weather brown. The middle of the series, with the thick sandstone mentioned above, is of a lighter tone, the sandstone being yellow and the shales light green or red. The top of the series is almost entirely red in colour, with some green and yellow beds of sandstone and occasional purplish layers.

Many unusual rock-types occur. In the upper beds the sandstones are almost invariably cornstones; that is to say, the angular sand-grains are scattered irregularly in an ophitic manner through large calcite crystals, whose cleavage remains quite apparent. The type is exactly similar to that found in the Upper Old Red Sandstone of Forfarshire.

Another type of cornstone, resembling some of those in the Lower Old Red of Herefordshire, in which the crystals are not apparent and the included material is very fine mud, if any is present at all, is also common in the upper beds, where it often surrounds bones.

In certain places masses of mudstone, usually of a purplish colour, are found, which are penetrated by irregular strings of calcite running in the main more or less vertically, but often branching and having the appearance of the roots of a plant. In one case (Donnybrook, Upper Zwoort Kei, District Queenstown) I found in association with such a rock reniform masses of clear crystalline calcite, about 4 cm. in diameter, in a deep red mudstone.

In the lower beds the mudstones contain immense numbers of nodules of irregular shapes, which are very hard and apparently only slightly calcareous; they sometimes surround bones, and their intractable nature adds much to the difficulty of working on South African fossil reptiles.

Clay-pellet conglomerates are common, particularly in the upper beds, where they often contain small fragments of bone. Pebbles are almost entirely absent; except for two or three found by Dr. Broom, none are known from this thick and very widely spread system.

The most remarkable features of the fossil contents which bear on the problem are—

1. The extraordinary rarity of Mollusca. During my own rather extended visit I saw no fossil shell of any kind, although they were carefully searched for. Dr. Broom, whose experience of the beds is unrivalled, has, I believe, only found one occurrence; and Mr. Whaits, in the course of a very considerable examination of the lower zones, has never met with them.

2. Fish are very rare. The only large group, that from the Caledon River described by Dr. Broom, is contained in bedded sandstones, and judging from specimens in museums those from other horizons are also usually in bedded shales and sandstones.

3. The great rarity of plant-remains, except in the clay-gall conglomerates, where pieces of wood are often seen. The only plant known to have been found in one of the mudstones that I am acquainted with is a bit of *Schizoneura* stem from Kuilspoort, District Beaufort West.

4. The fact that the definitely stratified shales very rarely yield any Tetrapod remains. Dr. Broom states that reptilian bones usually occur just below a sandstone, at the top of a mass of unstratified mudstone. This statement has been controverted by the Survey, but so far as my own observations go they support it, at any rate for the lower beds.

5. Tetrapod remains occur sporadically, and very large areas are practically free from them, although the rocks may be quite similar to those of the same age which are richly fossiliferous in other areas.

6. Reptilian remains often occur in associated sets. In museums such groups are very rare, but this is largely because the great majority of fossils are picked up completely weathered out, and the nodule containing the skull is the most obvious part. The very careful collecting of Mr. Whaits from the *Endothiodon* beds of the Beaufort West flats shows that by picking up all the small pieces of bone within a large area it is often possible to recover a good deal of the skeleton, even of such completely weathered-out specimens; the individuals are so rare that the chance of mixing the bones of two of them is comparatively slight. Where the face on which a fossil is exposed is steep, it is difficult to discover how much of a scattered skeleton is present. In my own experience bones found in situ were almost always associated with other parts of the skeleton. A. G. Bain's original manuscript catalogues show conclusively that many of the bones he sent to England were in associated lots. Reptilian remains sometimes occur in small groups, two or three individuals of the same or different individuals lying close together.

7. The fact that a much larger percentage of the bones found in sandstones belong to Stegocephalia than is the case with those in mudstones. I first noticed this fact in the upper beds of the Burghersdorp district, and examination of the remains in museums seems to confirm it very strikingly.

The problem of the mode of origin of the rocks which present the remarkable features detailed above is a difficult one. Bain in his first paper recognized that they were not of marine origin because of the entire absence of all salt-water shells. He considered them of lacustrine ,origin, an explanation which seems to have satisfied most observers to the present day. Stow, however, seems to have been doubtful about it.

It is interesting to compare the features of the Beaufort Beds recorded above with those of the Tertiary deposits of the Great Plains region of North America, also formerly considered as lacustrine. With suitable modification the following quotation from Leidy relating to them will apply to the Beaufort Series: "Whilst the geological formation makes it appear that the fossils were deposited in ancient lakes, or in estuaries or streams connected with the latter, it is strange that they exhibit no traces of fishes or of aquatic molluscs intermingled with the multitude of relics of terrestrial animals. . . . Even mammals of decidedly aquatic habitat are absent; with the exception of the shore-living rhinoceros and the beaver, no amphibious mammals have been discovered. Whilst the fossil bones are in perfect preservation, their original sharpness of outline without the slightest trace of erosion indicates quiet water with a soft muddy bottom." The work of Matthew, Fraas, and Hatcher has shown conclusively that these deposits are not of lacustrine origin, but were laid down on vast flat plains as flood-plain and river-channel deposits modified by wind-action. Matthew has shown that the river-channel sandstones contain the remains of forest- and river-living animals, whilst the fine clays enclose the skeletons of plain-living types.

The whole of the lines of evidence used by these geologists applies *mutatis mutandis* to the Beaufort Series. The vast majority of the Karroo reptiles are dry-land types. *Dicynodon*, which occurs throughout the entire series, is a large and very diverse genus, into which the Scotch *Gordonia* could be put; some of the South African types are, in fact, very similar to that form. *Gordonia* occurs in a sandstone all the grains of which are large and rounded, and in which the pebbles, occurring in thin impersistent bands, are all of characteristically wind-cut shapes; in fact, there is every reason to suppose that *Gordonia* is a desert animal. There can therefore be no doubt that *Dicynodon* is also a dry-land type.

Besides the Pelecypods and fishes, the only types that we have any reason at all for regarding as aquatic are *Lystrosaurus* and the Stegocephalia, the presence of lateral line sense-organs on the skulls of which shows that they must have been to some extent water-living.

I have pointed out above that the remains of fishes are apparently confined to the stratified shales and sandstones, and that the Stegocephalia, which are never common, are proportionately less rare in the sandstones.

Of the only two *Lystrosaurus* localities I visited, one was in very obviously bedded sandstones, the other in sandstone and not so well-bedded shales. The thick mass of sandstone referred to above as occurring on the Great Winterberg is apparently in the zone which yields this reptile.

We have therefore in the stratified and unstratified beds something of the same kind of difference of fauna that there is between Matthew's river-channel and flood-plain types of deposits.

The position in which skeletons are found is of interest. I know the position of seven skeletons of *Pariasaurus* as when found. In all cases the animal, which is a typical land-type, lay with its back upwards and its limbs still articulated; one skeleton that I collected lay prone, with its forelegs symmetrically disposed, the humeri at right angles to the body, and the forearms and hands stretched forward parallel to it. The ribs were naturally disposed, and the two femora lay forward in contact with the body, with the legs stretched out sideways. The whole skeleton, except for the skull, which had been weathered out, was absolutely complete, and looked as if the animal had died quietly, and been covered up without the slightest disturbance by brown dust.

A skeleton of *Procolophon*, only about 25 cm. long, lies absolutely complete, with every bone articulated, in the position dead lizards usually assume, with the hind-limbs stretched backwards along the tail and the soles of the feet inward. Had the Beaufort Beds been deposited in a lake, the places where these skeletons were found would have been more than a hundred miles from its shore; is it conceivable that they could have been transported this distance and then deposited in the exact position in which they died?

The extreme fineness of all the sediments implies that the agent which deposited them was incapable of moving anything larger than a small sand-grain; is it conceivable that it could have carried along the huge bones of *Pariasaurus* and the Deinocephalia?

Had the Beaufort Beds been deposited in a huge lake, we should expect to find very finely bedded shales full of plants, shells, and fishes, and containing occasional scattered bones; instead we find great masses of unstratified rocks with many sets of associated bones, and only very rarely, and then in stratified beds, fishes and plants.

The whole series of facts adduced above appear to me to be quite inexplicable on any lake theory of their origin, but receive a ready explanation if we suppose the deposits to have been laid down on land largely by wind-action, though also to some extent in small lakes or ponds, and perhaps wide and impersistent rivers. I think that it is not improbable that the curious cornstones may have had something to do with an efflorescence of calcareous matter similar to that which is now common in the Karroo.

It may perhaps be interesting to compare the great unbedded masses of mudstone with loess, which they resemble in the fact that their constituent particles are, in the sections I have at present examined, always angular, a common feature in fine wind-borne material.

In conclusion, I have to express my thanks to the Percy Sladen Trustees who assisted me to visit South Africa, and to many gentlemen there whose advice and assistance were of great service to me. I wish specially to thank Dr. R. Broom, Mr. D. V. Kannemeyer, and the Rev. Mr. Whaits.

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III.—ON THE GENUS *SYRINGOTHYRIS*, WINCHELL.

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(PLATE XII.)

1. Introduction.
2. Historical Review.
3. General Account of the Plate-like Structures in the Pedicle Valve of *Syringothyris*.
4. Detailed Account of the Structure of the Tube-bearing Plate (Transverse Plate) in a specimen of *Syringothyris* aff. *carteri* (Hall).
5. Relation between *Syringothyris* and certain Spirifers; and the Origin of *Syringothyris* in North America.

1. INTRODUCTION.

THE following account of the genus *Syringothyris* is the result of work undertaken at the suggestion of Professor T. F. Sibly, and is intended as a preliminary to a revision of the British species of that genus, which I hope to present at some future date.

Although it has long been known that *Syringothyris* possessed a distinctive internal structure referred to as a syrinx, or "a split tube between the dental plates", the exact relations of that structure had not been worked out, and it therefore seemed advisable to obtain a clear understanding of the characters of the genus, before attempting to deal with the mutual relations of its species.

To Professor Sibly I have to express my thanks, not only for his valuable advice and assistance while the work has been in progress, but also for his kindness in placing the necessary material at my disposal for study. My thanks are also due to Dr. A. Smith Woodward, F.R.S., for permission to examine and section specimens in the British Museum (Natural History), South Kensington, and to Mr. R. B. Newton, F.G.S., for assistance in searching the collections in the Museum.

2. HISTORICAL REVIEW.

The shell now known as *Syringothyris cuspidata* (Martin) was first described in 1796 by William Martin,[1] who named it *Anomia cuspidata*. The true nature of the fossil Brachiopoda had not at that time been recognized, and Martin regarded his shell as an *Anomia*, comparing its triangular fissure with the hole in the attached valve of that lamellibranch. The type-specimen, which is now preserved in the Sowerby Collection in the British Museum (Natural History),

[1] Martin, 1796, pp. 44–50.

South Kensington, was found in the Carboniferous Limestone of Castleton. It shows only the external characters of the shell; there is no trace of a pseudodeltidium, and the delthyrium is filled with matrix so that the tube-bearing plate which is characteristic of *Syringothyris* cannot be seen.

In 1815 James Sowerby founded his genus *Spirifer*, with *Anomia striata*, Martin, as his genotype,[1] and stated that he suspected *Anomia cuspidata* to have coils similar to those which he had observed in *Anomia striata*. This statement, and the fact that in *Mineral Conchology*, vol. ii, p. 43, 1818, which was published before the paper to the Linnean Society was printed, Sowerby mentioned the species *cuspidatus* as an example of his genus *Spirifer*, led William King,[2] Meek,[3] and others to regard *S. cuspidatus* as the genotype of *Spirifer*; but Davidson[4] has shown that Sowerby always regarded *S. striata* as the type-species of his genus.

Spirifer cuspidatus was mentioned by various authors, but no additional characters were described until 1836, when G. P. Deshayes[5] noted the presence of a plate (the pseudodeltidium) covering the delthyrial fissure.

In 1855 F. M'Coy[6] stated that in *Spirifer cuspidatus* (Martin) the triangular delthyrium often displayed "an internal deep-seated pseudodeltidium". In the absence of a figure, it is not certain whether the structure referred to was the tube-bearing plate, but it is probable that it was since the upper surface of that plate is often seen between the so-called 'dental plates', a little below the level of the cardinal area of the shell.

In 1863 Alexander Winchell[7] described certain fossils from the yellow sandstones beneath the Burlington Limestone (Lower Mississippian) of Iowa. Among these were shells which externally resembled *Spirifer cuspidatus* (Martin), but which possessed, in the pedicle valve, beneath the pseudodeltidium and between the so-called 'dental plates', an arched transverse plate. On the lower surface of this plate were two nearly parallel lamellæ, incurved at their free ends so as to nearly meet, forming a tube, incomplete along its lower surface, and projecting beyond the limits of the plate from which it originated. For these shells Winchell proposed the name *Syringothyris*, in allusion to the split-tube or syrinx, and the large triangular fissure or delthyrium. He named his type-specimen *Syringothyris typa*.

Subsequently Davidson, King, and others observed that *Spirifer cuspidatus* (Martin) possessed a similar plate and syrinx; and these authorities regarded *Syringothyris typa*, Winchell, as synonymous with *Spirifer cuspidatus* (*Syringothyris cuspidata*). Schuchert,[8] however, pointed out small differences which led him to regard these two species as distinct forms. At the same time he concluded that *Syringothyris typa* (1863) was identical with *Spirifer carteri*, Hall (1857), which latter shell first occurs in the Bedford Shale of Ohio (lowest division of the Mississippian). Accepting the specific value

[1] Sowerby, 1818, p. 515.
[2] King, 1850, p. 125.
[3] Meek, 1864, p. 19.
[4] Davidson, vol. i, p. 81.
[5] Deshayes, 1836, p. 368.
[6] M'Coy, 1855, p. 426.
[7] Winchell, 1863, pp. 2–25.
[8] Schuchert, 1889, pp. 28–37.

of the differences between *S. cuspidata*, Martin, and *S. typa*, Winchell, and also the identity of *Syringothyris typa* with *Spirifer carteri*, Hall, *the last-named species, having priority, becomes the type-species of the genus* SYRINGOTHYRIS.

The differences between *Syringothyris carteri* (Hall) and *S. cuspidata* (Martin), as defined by Schuchert, are confined to external characters, and are as follows: the area of the pedicle valve is flat or concave in *S. carteri*, while in *S. cuspidata* it is usually reclined; and in *S. carteri* the lateral slopes of the pedicle valve are slightly convex, while in *S. cuspidata* they are flat or nearly flat. These differences are practically the same as those between *Syringothyris* aff. *cuspidata*, of authors, from the *Cleistopora* and *Zaphrentis* zones of the South-Western Province, and Martin's specimen from the Viséan of Castleton, or *S. cuspidata* from the Carboniferous Limestone (*Syringothyris*-zone ?) of Kildare.

Winchell did not figure any of his specimens, but *Syringothyris typa* has been figured by Hall & Clarke[1] and *S. cuspidata* by Davidson[2] and King.[3]

3. General Account of the Plate-like Structures in the Pedicle Valve of *Syringothyris*.

(1) *The Delthyrium and Pseudodeltidium.*—The cardinal area in the pedicle valve of *Syringothyris* is interrupted by a triangular delthyrium as in other brachiopods. It is only on rare occasions that any plate is preserved covering the delthyrium, but occasionally the delthyrium is partly closed by a convex pseudodeltidium, the distal end of which is concave towards the apex of the shell, leaving a semicircular opening between itself and the hinge-line. Specimens in which this plate is preserved have been figured by Hall & Clarke[4] and Davidson.[5] When the pseudodeltidium has been lost two grooves into which its edges fitted can often be seen, one on either side of the delthyrium.

In *Syringothyris cuspidata* the pseudodeltidium has no foramen such as occurs in *Cyrtia*. Davidson[6] figured an internal cast of a pedicle valve from the Carboniferous Limestone of Breedon Hill, in which, he maintained, "the deltidium was in reality perforated by a circular foramen." His specimen shows, however, not a foramen in the pseudodeltidium, but a cast of the syrinx characteristic of *Syringothyris*.

Some authors, for example, King[7] and more recently Woods[8] and Cowper Reed,[9] have used the term deltidium for the covering plate

[1] Hall & Clarke, 1894, pl. xxvi, figs. 6, 7, 10; pl. xxvii, figs. 1–3.
[2] Davidson, vol. ii, pl. viii, figs. 19–24; pl. ix, figs. 1, 2; vol. iv, pl. xxxiii, figs. 1–3.
[3] King, 1868, pls. ii, iii.
[4] Hall & Clarke, 1894, pl. xxvii, fig. 15.
[5] Davidson, vol. iv, pl. xxxiii, fig. 1.
[6] Davidson, vol. ii, pl. viii, footnote, and pl. ix, fig. 1.
[7] King, 1850.
[8] Woods, Palæontology, Invertebrate, p. 157.
[9] Cambridge Natural History, vol. iii, p. 498, 1895.

of the delthyrium in the Telotremata, but Hall & Clarke[1] have shown that 'pseudodeltidium' was proposed by Bronn for the fused condition of the deltidial plates that may occur in the Telotremata, while the term deltidium was intended to be used for the simple pedicle-secreted plate in the Protremata and in some Neotremata. Davidson used the terms indiscriminately, and referred to the plate in *Syringothyris* and the Spirifers generally, sometimes as a deltidium and sometimes as a pseudodeltidium. Hall & Clarke proposed to replace the terms 'deltidial plates' and 'pseudodeltidium' by 'deltaria' and 'deltarium' respectively, but this seems unnecessary if the original definitions of deltidium and pseudodeltidium are adhered to.

(2) *The Delthyrial Supporting-plates.*—Extending from the edges of the delthyrial fissure into the interior of the pedicle valve are the so-called 'dental plates' such as are developed in other brachiopods. They are slightly divergent, and in the neighbourhood of the apex reach the floor of the valve; but as the hinge-line is approached they become very shallow, and are widely separated from the floor of the valve. The function of these plates in the Orthotetids has been discussed by Dr. Ivor Thomas,[2] who suggests that they should be called delthyrial supporting-plates, since their almost complete disappearance before the teeth are reached would make it appear that their function is not so much to support the teeth, as to increase the stability of the area where it is interrupted by the fissure. This would apply with even greater force in the case of *Syringothyris*, where the area is so high; and the term 'delthyrial supporting-plates' will therefore be used in this paper in preference to 'dental plates'.

(3) *The Tube-bearing Plate, or Transverse Plate.*—Connecting the vertical delthyrial supporting-plates is a horizontal plate which extends for from one-half to two-thirds of the distance from the apex to the hinge-line. This plate is not the pseudodeltidium, but lies below it. Its distal end is concave to the apex of the shell, and attached to its lower surface is an incomplete tube which projects for a short distance beyond the limits of the plate. On the upper surface of the plate there is a median longitudinal ridge. In passing from the apex towards the hinge-line the tube-bearing plate gradually plunges beneath the level of the cardinal area.

This tube-bearing plate developed between the delthyrial supporting-plates of *Syringothyris* is the distinctive feature of the genus.

As already mentioned, the general characters of this plate and tube have often been described, but their precise structure and relations have not been understood. This is probably due to the state of preservation of the shells examined. The structural details only become really clear when the shell is preserved in a fine-grained rock of such a colour that any shell structure which may be present is clearly defined. Most of the specimens from Derbyshire and Ireland are unfortunately filled with crystalline calcite, which tends to obscure the internal characters of the shell.

[1] Hall & Clarke, 1894, pp. 327–8.
[2] Ivor Thomas, 1910, pp. 100–1.

4. Detailed Account of the Structure of the Tube-bearing Plate (Transverse Plate) in a specimen of *Syringothyris* aff. *carteri* (Hall). (Plate XII.)

The specimen here described was obtained by Professor T. F. Sibly from the Upper *Cleistopora* Zone (K_2) of the Post Office Quarry at Howle Hill, in the Forest of Dean area, Gloucestershire. It is of a type that is common in the Upper *Cleistopora* Zone and in the *Zaphrentis* Zone of the South-Western Province, and which, as mentioned by Dr. Vaughan,[1] has broad flat ribs on the pedicle valve. This type of shell differs in certain respects (height and convexity of area, etc.) from the Derbyshire and Kildare specimens, and is more nearly related to *Syringothyris carteri* (Hall) than to *S. cuspidata* (Martin). The consideration of these differences is, however, best deferred until a future paper, when the species of *Syringothyris* will be dealt with in detail.

Owing to the nature of the matrix, a fine-grained yellow limestone, and the excellent preservation of the shell substance, the specimen was peculiarly suitable for study of the internal characters.

The pedicle valve of the shell was rubbed down in a plane at right angles to the area, and sections drawn at intervals of about half a millimetre. The beak of the valve was slightly damaged, and the first satisfactory section was obtained at a distance of 4 mm. from the apex. The following sections are selected as illustrating the more important stages. (See Plate XII, Figs. 1–8.)

Figs. 1 and 1*a*. Distance from the apex 4 mm. In this section there are two strong divergent plates crossing the valve from the cardinal area to the floor. Each plate is divided longitudinally into halves by a distinct line. The outside moiety (the true delthyrial supporting-plate) in each case is continuous with the shell substance of the cardinal area, while the inside portion curves over at the top, and meeting its fellow from the opposite side forms an arch-shaped plate (the transverse plate) between the delthyrial supporting-plates, and which when seen from above appears as a septum connecting those plates.

Figs. 2 and 2*a*. Distance from the apex 6 mm. Here the sides of the arch-shaped plate are thinner than the delthyrial supporting-plates, which are themselves thinner than in the previous section. In the transverse portion of the arch there is a circular mark which represents the cavity of a tube, filled and obscured by shelly matter during the subsequent growth of the plate. On the upper surface of the plate there is a slight median ridge, also seen in the subsequent sections.

Figs. 3 and 3*a*. Distance from the apex 11 mm. Between this section and the previous one, the delthyrial supporting-plates have become thinner at their bases, until in the present section one of them fails to reach the floor of the valve. The limbs of the arch-shaped plate are shorter than and thin out against the delthyrial supporting-plates. The outline of the tube or syrinx is very distinct, but its cavity is still filled with shelly matter.

[1] Vaughan, Q.J.G.S., vol. lxi, p. 301, 1905.

Figs. 4 and 4*a*. Distance from the apex 14 mm. The delthyrial supporting-plates are here very short. In the transverse plate the cavity of the tube and its inferior opening are very clear. This section, in which the transverse plate and split tube are perfectly developed, may be taken as *a type-section of the essential characters of the genus*, and constitutes a standard to which sections of other specimens can be referred.

Figs. 5 and 5*a*. Distance from the apex 15 mm. In the sections following that shown in Fig. 3, the limbs of the arch become shorter and shorter until they are mere flattenings of the edges of the transverse plate. The plate itself and the wall of the tube become thinner. The conditions at this stage are shown in Fig. 5.

Figs. 6 and 6*a*, 7 and 7*a*. Distance from the apex 16 and 17 mm. respectively. The transverse plate eventually disappears, except for two small portions, one applied to each of the delthyrial supporting-plates, leaving the syrinx quite free as in Fig. 6. At the same time the syrinx becomes smaller and its walls thinner, while its roof assumes a folded aspect. In Fig. 7 the lateral portions of the transverse plate have disappeared, as have also the side walls of the syrinx, leaving only the roof of the syrinx, continuing as a ridged and folded lamella which becomes gradually smaller and finally disappears. (In this specimen, at a distance of 19 mm. from the apex of the shell.)

In the earlier sections (Figs. 1–3) there is a low ridge on the floor of the valve between the delthyrial supporting-plates. This ridge or crest divides the anterior portion of the muscular impressions, and resembles the median crest which occurs in *Spirifer*, *Productus*, and many other brachiopods, but contrasts very strongly with the elevated median septum which occurs in a similar position in *Spiriferina*.

In a band of dolomite in the Lower *Zaphrentis* Zone (Z_1), exposed in the Cement Works Quarry at Mitcheldean, Glos, internal casts of *Syringothyris* of the type already described are abundant, and many specimens have been collected by Professor Sibly. The shell substance has been removed by solution, but the characters of the shell are very clearly shown by the matrix, with which the valve was filled. The delthyrial supporting-plates and the transverse plate are represented by space, and the cavity of the syrinx by a rod (*r*, Figs. 8, 8*a*) lying in a groove on the surface of the matrix that filled the chamber between the delthyrial supporting-plates. The lower surface of the rod is connected with the floor of the groove by a narrow plate representing the slit in the syrinx. The muscular impressions on the floor of the pedicle valve and the crest which separates them are clearly defined in these casts. It was from a similarly preserved specimen that Davidson inferred the presence of a foramen in the pseudodeltidium of *Syringothyris cuspidata* (see p. 395).

We have seen that the transverse plate of *Syringothyris* arises in the apex of the shell as an arch-shaped plate, between and applied to the delthyrial supporting-plates, but not as an integral part of those plates. The syrinx occurs on the lower surface of the plate, and is formed by two nearly parallel lamellæ, the free ends of which curve towards one another. As the distance from the apex of the shell increases, the lateral portions of the arch become thinner and shorter until only its roof persists as the tube-bearing or transverse plate—a slightly convex plate, down the centre of which is a median ridge on the upper surface and a slit tube or syrinx on the lower surface. The transverse plate itself then dies out. Its distal end is concave towards the apex of the valve, and the syrinx projects for a short distance beyond it. The slit on the ventral surface of the tube tends to close, and the tube itself to be obscured by the further deposition of shelly matter on the earlier-formed portion of the transverse plate. In discussing the homology of the plate, Winchell[1] stated that in many Spirifers there is "an indication of a longitudinal folding of the dental plates which may produce on one side or the other a laminar process", and he suggested that the plate of *Syringothyris* may be of this nature, but in view of the sections that have been described this view appears to be untenable.

5. Relation between *Syringothyris* and certain Spirifers; and the Origin of *Syringothyris* in North America.

There is, developed between the delthyrial supporting-plates of certain Spirifers, a short transverse plate resembling in position and mode of origin the tube-bearing plate of *Syringothyris*; and the following sections (Plate XII, Figs. 9–11) across the beak of the pedicle valve of *Spirifer duplicicosta*, Phillips, from the Carboniferous Limestone (Viséan) of Park Hill, Derbyshire, may be compared with those of *Syringothyris* (Plate XII, Figs. 1–7).

Fig. 9. Distance from the apex 3 mm. This section should be compared with Fig. 1; at this stage the structure of the two shells is essentially the same.

Fig. 10. Distance from the apex 5 mm. This corresponds in position with Fig. 4, and it will be seen that although the relation between the transverse plate and the delthyrial supporting-plate is the same in each case, there is no trace of a tube in the present section.

Fig. 11. Distance from the apex 8 mm. This section corresponds to a stage between Figs. 5 and 6. The plate is incomplete in the centre owing to its concave extremity as in *Syringothyris*, and in a further section, 11 mm. from the apex, it does not appear at all.

A similar transverse plate was observed by the writer in a large specimen of *Spirifer striata* (Martin) from Kildare. King[2] claimed to have seen in a specimen of *S. striata* a transverse plate in which there was actually a tabular canal, but this has not been verified.

Origin of Syringothyris *in North America.*—The plate just described as occurring in *Spirifer duplicicosta*, Phillips, and *S. striata* (Martin) is also found in many Devonian Spirifers of North America, and has been described and figured by Hall & Clarke,[3] who call it a delthyrial callosity. In North America there appears to have been

[1] Winchell, 1863, p. 7.
[2] King, 1868, p. 18, and pl. ii, fig. 25.
[3] Hall & Clarke, 1894, pls. xxiii, xxiv, etc.

a gradual change from the simple plate extending across the delthyrial fissure in certain Spirifers, e.g. *S. granulosus*, Conrad (from the Hamilton Shale, Upper Middle Devonian), to the tube-bearing plate of *Syringothyris*; while in other forms the plate has persisted without change, and occurs as a simple transverse plate in many Carboniferous Spirifers. A transitional stage is seen in *Spirifer altus*, Hall,[1] where the transverse plate bears on its ventral surface a median longitudinal ridge. Girty,[2] indeed, regards *Spirifer altus*, Hall, as the direct progenitor of *Syringothyris*. The syrinx appears to have arisen by the growth of the lateral margins of the ridge, giving rise to two lamellæ, the free ends of which curled towards one another forming an incomplete tube. In North American Spirifers, therefore, the simple transverse plate developed between the delthyrial supporting-plates in certain Devonian forms gave rise to the tube-bearing plate of *Syringothyris*, and the earliest form in which the syrinx is perfectly developed is *Syringothyris carteri* (Hall) (= *S. typa*, Winchell) from the Bedford Shale (Lower Mississippian) of Ohio, which formation contains a fauna allied to, and apparently in part derived from, the Middle Devonian Hamilton fauna.[3]

In this country, however, the genus *Syringothyris* appears with all its essential characters in the *Cleistopora* Zone of the South-Western Province, and its early development is not known. Its ancestors may yet be found among the Devonian Spirifers of this country or Belgium.

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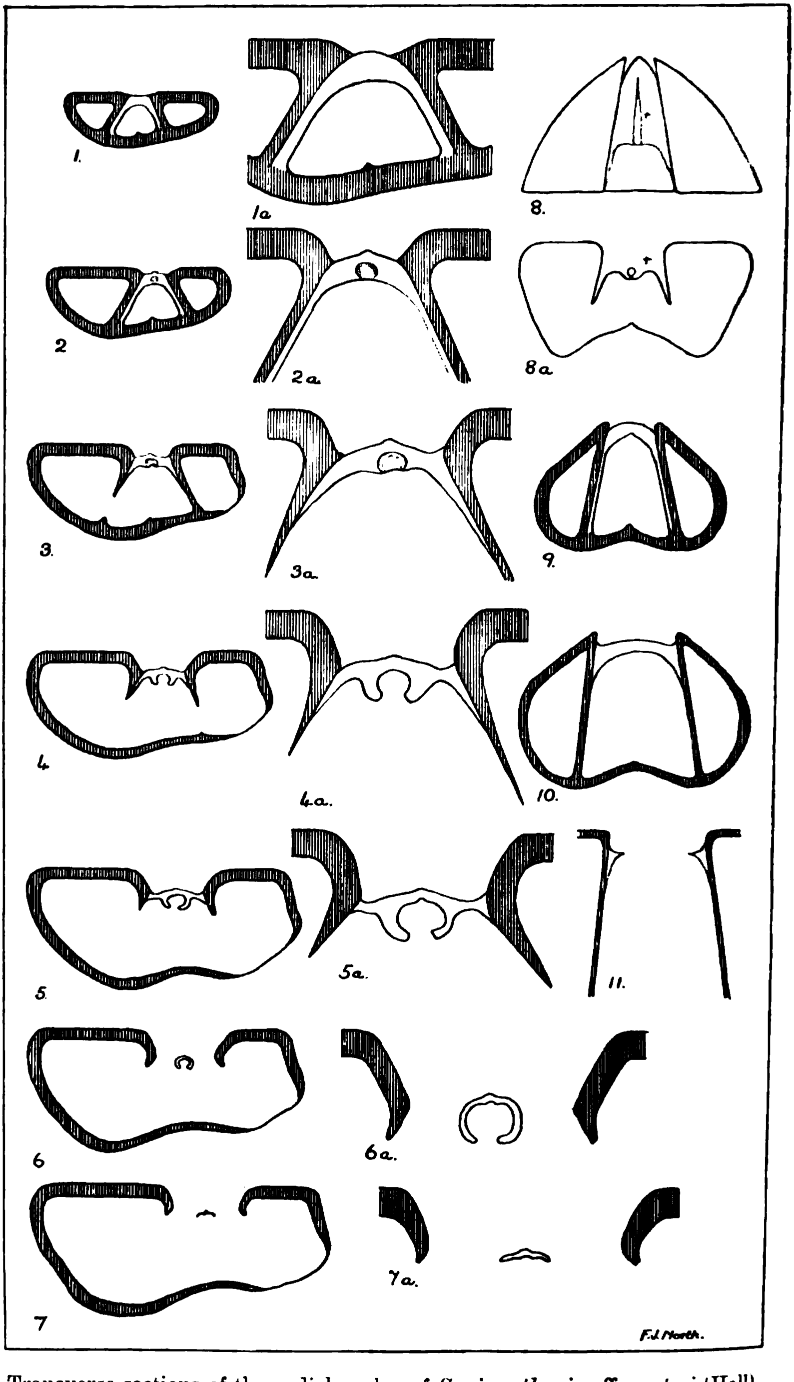
[1] Hall, 1867, pp. 248–9, pl. xliii, figs. 1–7. A form allied on external characters to the European *Spirifer simplex*, Phillips.

[2] Girty, 1900, p. 51.

[3] Bailey Willis, 1912, p. 409.



Transverse sections of the pedicle valve of *Syringothyris* aff. *carteri* (Hall) and *Spirifer duplicicosta*, Phillips.

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EXPLANATION OF PLATE XII.

FIGS. 1–7. *Syringothyris* aff. *carteri* (Hall). Carboniferous Limestone Series, Sub-zone K_2: Howle Hill, Forest of Dean area. Transverse sections of pedicle valve. Natural size.

,, 1*a*–7*a*. Delthyrial supporting-plates and tube-bearing plate of the previous sections, enlarged. × 3.

,, 8–8*a*. *Syringothyris* aff. *carteri*, Hall. Z_1. Mitcheldean. Fig. 8, internal cast of the pedicle valve, diagrammatic, showing the rod (*r*) representing the cavity of the syrinx; Fig. 8*a*, transverse section, diagrammatic.

,, 9–11. *Spirifer duplicicosta*, Phillips. Carboniferous Limestone: Park Hill, Derbyshire. Transverse sections of the pedicle valve. × 3. In Fig. 11 only the central portion of the section is indicated.

IV.—THE LOWER PLIENSBACHIAN—'CARIXIAN'—OF CHARMOUTH.

By W. D. LANG, M.A., F.G.S.

I. THE GREEN AMMONITE BEDS.

THE Green Ammonite Beds of the Lias (called also the Wear Cliff Beds in the latest Survey publication on Lyme Regis)[1] include the clays with occasional limestones that lie between the Belemnite Stone below and the lowest of the Three Tiers above. The lowest Tier contains ammonites of the *margaritatus* group,[2] and the Belemnite Stone caps the top beds of the Belemnite Marls that may be placed in the *ibex–valdani* zone.[3] So the Green Ammonite Beds may be said to constitute the upper part of such of the Pliensbachian or Charmouthian as lies below the Domerian.[4] Buckman has applied the term 'Charmouthian' to this lower portion, thus restricting the term to a part only of what it originally included.[5] I have already advocated the propriety of applying the term Charmouthian strictly with its original connotation,[6] and would call those zones of it that lie below the Domerian,—Bonarelli's 'Charmoutiano inferiore'—which certainly need an inclusive name, Carixian.[7] The fullest published accounts of the Green Ammonite Beds are those in the

[1] Woodward & Ussher, *The Geology of the Country near Sidmouth and Lyme Regis* (Mem. Geol. Surv. Eng. and Wales), 1911, 2nd ed., p. 31.

[2] Throughout this paper the phrase "ammonites of the —group" is used, rather than the specific name of the ammonite, implying that several, presumably related forms are included under one designation.

[3] On the evidence of *Acanthopleuroceras ellipticum* (James Sowerby), a form that comes very near to *A. valdani*. Mr. S. S. Buckman kindly identified this form for me.

[4] Bonarelli, Atti della R. Accad. d. Scienze di Torino, vol. xxx, pp. 84–5, 1894.

[5] Buckman, *Yorkshire Type Ammonites*, pt. ii, p. xvi, 1910.

[6] Lang, GEOL. MAG., Dec. V, Vol. IX, p. 284, 1912.

[7] "Charmouth, the Carixa of Ravennas" (Roberts, *The History of Lyme Regis, Dorset*, 1823, p. 220). The derivation seems obvious—*Char-isca*, 'Char-river.'

Survey Memoirs,[1] and may be summarized as follows: They extend from Black Ven on the west to Seatown on the east; traces only appear on Black Ven; the complete series occurs on Stonebarrow, though there "only the lower portion is well-exposed"; their thickness is about 100 feet, though variable, and as much as 125 feet to the east of Golden Cap; they consist of marly clays with 'ferruginous bands' and nodular limestones. Eight detailed subdivisions are given.

Now this description in the Survey Memoirs, though excellent as far as it goes, is not of much help for tracing the vertical distribution of the ammonites or other fossils contained in the beds here described; the first step towards which is to be able to tell, when collecting in any section, the exact position in the series of the bed whence the specimens are being taken. For this it is necessary to know what lithic characters are constant throughout the whole exposure of the beds, and what are local accidents; also how the thickness of the whole series varies, so that measurements taken from the same bed at different spots may be correlated. It is proposed to give the stratigraphical results of some years' collecting, both as a guide to future work and to supplement the descriptions in the Survey Memoirs. It may be here remarked that although adding to and even criticizing the account in the Survey Memoirs, this further description would never, probably, have been written without it; and these new subdivisions are now put forward with full acknowledgment of the help obtained from the publications of the Survey.

It must be stated also that the following remarks do not include the Green Ammonite Beds east of Golden Cap. From Golden Cap to Seatown (where they are faulted away)[2] is about a mile, and their total extent in the cliffs about four miles. It is therefore possible that any apparent discrepancies in the Survey Memoir may be due to observations made east of Golden Cap; as is certainly the case with the sandy beds recorded as appearing below the Three Tiers, of which the author has not found more than traces, nor these as a constant feature. Nevertheless, the similarity (except in thickness) of the Green Ammonite Beds from Black Ven through Stonebarrow to Golden Cap is so close that it would be surprising if they changed considerably in that eastern mile.

Three constant and more or less continuous limestones break the monotony of the Green Ammonite clays (see Diagrams I and II). The most conspicuous, continuous, and easily recognized of these is the Red Band. It is well known to the Charmouth fishermen, who, when they want (for sale to visitors) a 'henleyi' as they call ammonites of the *striatus* group, go up Stonebarrow and pick away at the Red Band. There can be no mistaking the curious pink-red weathering of this muddy limestone. When fresh, it is hard and firm; but being only about 6 inches to a foot thick, it is generally weathered nearly to the core, and is then grey-brown and in

[1] Woodward & Ussher, op. cit., 1911; and op. cit., 1906, 1st ed.; H. B. Woodward, *The Lias of England and Wales* (Mem. Geol. Surv. United Kingdom), 1893, p. 68.

[2] See H. B. Woodward, op. cit., 1893, p. 52.

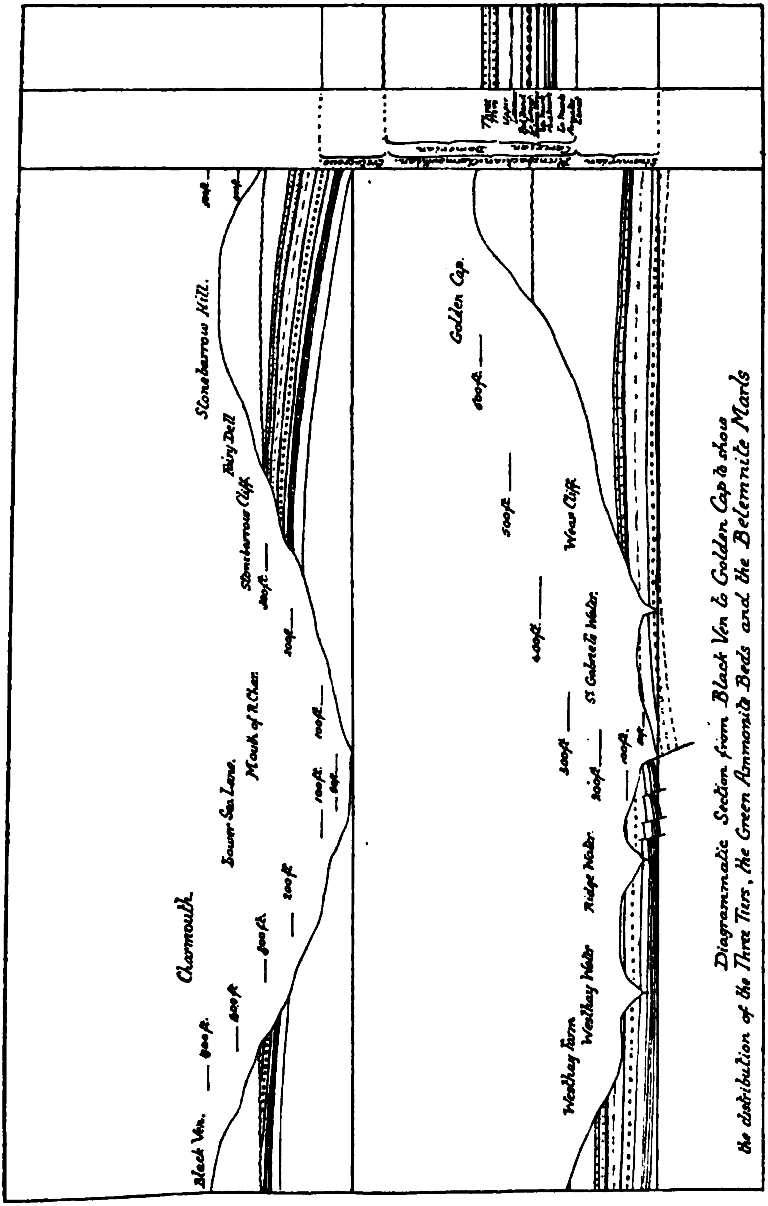


DIAGRAM I: SECTION FROM BLACK VEN TO GOLDEN CAP.

Scale about 3¼ inches to a mile.

a crumbling, muddy condition, becoming pink-red on its surface. A little Crinoid is common and characteristic of it; also a *Nucula*; its commonest ammonites are those of the *striatus* group; *Tragophylloceras loscombi* (James Sowerby) and *Deroceras davœi* (James Sowerby) also occur; as well as *Nautilus* and Gastropods. I have not found the Red Band in place on Black Ven, but fallen blocks may be found above the Lower Limestone at the extreme eastern outcrop of the Green Ammonite Beds on that cliff, showing that it is just included there before the Lias is truncated by the Gault. Some twenty yards west of where the blocks were found there was a section[1] (now unfortunately foundered) showing the junction of the Lias and Gault. The Lower Limestone was to be seen in place some seven feet above the Belemnite Stone, six feet of clay above the Lower Limestone, and then the junction before the Red Band was reached. So the Red Band has a very short range on Black Ven. On Stonebarrow Cliff it may be found west of Fairy Dell,[2] on the slope of broken ground above the precipice formed by the Belemnite Marls, at some height above the 200 ft. contour-line, and followed across the grassy places until, still before Fairy Dell is reached, its outcrop is mostly on the cliff-face. Thence it runs eastward under the more inaccessible parts of Fairy Dell, sometimes on the cliff-face, but generally on broken ground above the clean section. It is conspicuous just above the 100 ft. contour in a semicircular section on the undercliff between Westhay Farm and the sea, close to the 'y' in 'Folly' on the six-inch Ordnance Survey map, and again immediately west of Westhay Water at 105 feet, and may be seen at the head of the gully above the waterfall of that stream. The red weathering of the top and bottom surfaces, in contrast to the grey middle, is so marked in the Red Band as seen near Westhay Water that the Band appears from a distance to be double, a condition it more nearly assumes further east, beyond the Ridge fault. Nearly a quarter of a mile east of Westhay Water is the little waterfall known as Ridge Water, which is in the trough of a syncline, since east of it the beds have a westerly dip. Rather less than 300 yards east of Ridge Water, the cliff ends abruptly in a big fault that lets the beds down about 100 feet[3] on the east. Between Ridge Water and this big fault are three little step-faults with a downthrow on the east of from 10 to 20 feet. They do not, however,

[1] Described, Lang, Geol. Mag., Dec. V, Vol. I, pp. 125, 126, 1904. It was visited by the Geologists' Association in 1906, see Proc. Geol. Assoc., vol. xix, pt. ix, p. 323.

[2] The great undercliff on Stonebarrow, called 'Cain's Folly' on the six-inch Ordnance Survey map. I use the more familiar local name.

[3] The Survey, following Day (Quart. Journ. Geol. Soc., vol. xix, p. 282, 1863), give a downthrow of only 40 feet (see H. B. Woodward, op. cit., 1911, p. 30); but considering that at this point the Red Band is reckoned at 45 feet above the Belemnite Stone, it must be about 95 feet above the beach on the west side of the fault, while it is beneath the beach 5 or 6 feet below the cliff-base on the east side of the fault; hence 100 feet is a fair minimum estimate of the downthrow. It is possible that there is a second fault a few yards further east, sharing the 100 ft. downthrow with the obvious fault, but this has not yet been definitely ascertained, and at any rate does not affect the present question.

affect the position of the beds as a whole, since owing to their somewhat steep westerly dip these recover between successive faults the distance fallen (see Diagram I). The big Ridge fault brings down the Red Band from the rough ground above the Belemnite Stone to some feet under the beach and out of sight; but at about 50 yards east of the fault it rises from the beach (the dip here is still westerly) on to the low cliff, and in two 6 in. bands about a foot apart, follows this cliff as it rises to some height eastwards, across St. Gabriel's Mouth, and so well up on to Wear Cliff, Golden Cap. Here it is about 40 feet up the cliff, when the dip reverses, and it begins to descend again. The Belemnite Stone may be seen in the angle between the cliff and the beach beneath the western part of Wear Cliff; so at Golden Cap the Red Band is about 40 feet above the Belemnite Stone, whereas at Westhay Water there are 49 feet, at the western end of Stonebarrow only about 20 feet, and on Black Ven but 14 feet between them.

The Lower Limestone, the second constant feature of these beds, is of very different appearance. Sharp, hard, nodular, and impersistent, it presents a marked contrast to the Red Band, which generally is seen in a soft, weathered condition, and occurs in continuous slabs rather than in discontinuous nodules. In spite of its nodular, impersistent nature, the Lower Limestone is remarkably constant in its appearance about half-way between the Belemnite Stone and the Red Band, and may be counted on with certainty in an appropriate section of some size, if it is looked for with care. Its characteristic fossils are ammonites of the *latæcosta* group; it contains also *Tragophylloceras loscombi* (James Sowerby); occasionally, too, a *Straparollus*; but fossils other than ammonites are rare in this rock. It occurs 7 feet above the Belemnite Stone on Black Ven; 10 feet at the western end of Stonebarrow Cliff; 21 feet at Westhay Water (where it is poorly developed and consequently difficult to find); and about 20 feet above the Belemnite Stone on the western face of Golden Cap. After being thrown down by the Ridge fault, it can be picked up rising from the beach some forty yards east of the reappearing Red Band.

The Upper Limestone is less easily found than the Red Band or the Lower Limestone. It appears half-way between the Red Band and the Lowest Tier. Like the Lower Limestone it is often sharp and nodular, but the nodules tend less to a spherical shape. On the western side of Stonebarrow, however, it is either flaggy and tends to be sandy like the Three Tiers, or is nodular and calcareous with a sandy shell; and it may change abruptly within a few yards from one to the other condition. The sandy beds mentioned in the Survey Memoir as occurring below the Three Tiers may be this rock, only they are comparatively higher in the Green Ammonite Beds Series. The Upper Limestone is above the highest Lias on Black Ven; but it may be found at the western end of Stonebarrow 35 feet above the Belemnite Stone or 15 feet below the lowest Tier. The ground, however, at this horizon is very broken on Stonebarrow, and it is not often that a section can be found in it. On the western side of Golden Cap, the Upper Limestone may be found 30 feet below the

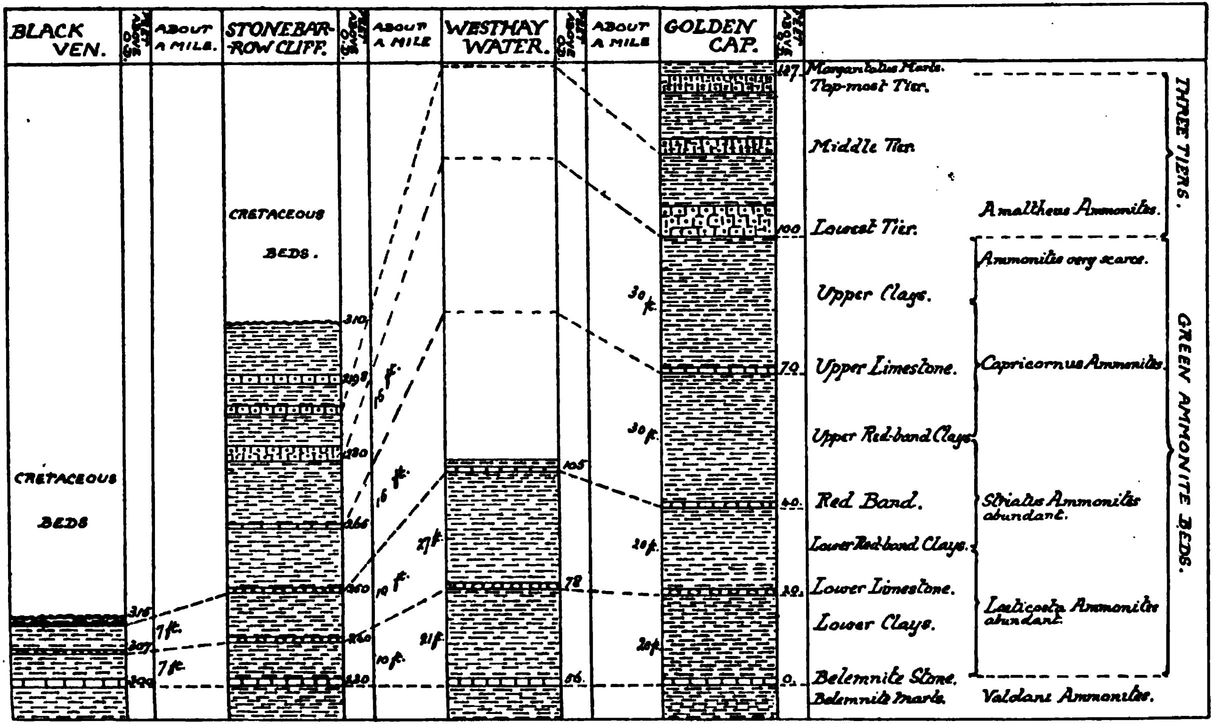


DIAGRAM II: DETAILED SECTIONS OF THE THREE TIERS AND GREEN AMMONITE BEDS, SHOWING THEIR VARYING THICKNESS AT DIFFERENT POINTS.

lowest Tier, and about 70 feet above the beach. The only fossil common in this bed is *Tragophylloceras loscombi* (James Sowerby).

Of the four clay masses included within the Green Ammonite Beds, the topmost, the Upper Clay, contains many *capricornus*-like ammonites, and an *Arca* is fairly common, all in a filmy condition, and small pyritic casts of *Tragophylloceras loscombi* (James Sowerby). The second bed, the Upper Red-Band Clay, has similar fossils and in addition pyritic casts of ammonites of the *bechei* and *latæcosta* groups. The third, the Lower Red-Band Clay, in the upper part contains chiefly well-preserved *T. loscombi* (James Sowerby) and, rarely, *Deroceras davæi* (James Sowerby) in films, and, in the lower part, abundant *Straparollus* of two or three species, other small gastropods, young pyritized *T. loscombi* (James Sowerby), and ammonites of the *latæcosta* group. And the lowest bed, the Lower Clay, fossils similar to those in the lower part of the bed above.

It should be clear from the above description that there is a considerable thinning of the Green Ammonite Beds as they pass westwards.[1] In fact, at the western end of Stonebarrow their thickness is only half of what it is on the western side of Golden Cap; while on Black Ven, what remains of them gives evidence of further and proportional thinning. The variation is not, however, quite regular, since at Westhay Water the series appears to be slightly thicker than on the western face of Golden Cap. This diminution affects the whole series equally, so that the thickness of its subdivisions varies directly with that of the whole. Moreover, the Three Tiers share in the diminution, and may be seen on Stonebarrow shorn of half that development they display on Golden Cap.[2] The lower two Tiers may be seen in place on Stonebarrow Cliff in the banks bordering the great hollow formed by a fall of the cliff (1908–9) beneath the beeches and pine-trees immediately west of Fairy Dell; and the Lowest Tier again on the cliff just west of this. The Lowest may be known from the two higher Tiers by being nearly twice as thick (in the same section) as either of these, and far more fosiliferous. Its chief fossils are ammonites of the *margaritatus* and *loscombi* groups and small gastropods. The Tiers are next seen about a hundred yards further east, at the western end of Fairy Dell, just east of the top of a big gully that makes it possible to climb the Belemnite Marls at this point. The gully is blocked in places by large masses of the Lowest Tier. In the section above it all three Tiers were to be seen in place and a few feet of Margaritatus Marls above them. The section, however, during the last year (1912–13) has foundered and is much obscured. The two higher Tiers with Margaritatus Marls above may be seen again beneath the junction of the Lias and Gault in the Lias bank that breaks through the overgrown expanse of Fairy Dell in its eastern part.

It was conjectured in a former paper[3] that the base of the Cretaceous on Stonebarrow was at about 320 feet O.D. It now appears that this is at least 10 feet too high, and the actual heights are probably

[1] See GEOL. MAG., Dec. V, Vol. IX, p. 285, 1912.
[2] See GEOL. MAG., loc. cit., 1912.
[3] Lang, GEOL. MAG., Dec. V, Vol. IV, p. 150, 1907.

those given in the accompanying diagram. If these are right, the base of the Cretaceous on Stonebarrow is slightly lower than on Black Ven, contrary to Jukes-Browne's surmise. This does not, however, affect the validity of Jukes-Browne's main argument.[1]

It remains to be seen if any correspondence can be established between the sequence given in this paper and the eight subdivisions of the Green Ammonite Beds in the Survey Memoirs. The detailed section given in the Memoirs[2] is about 100 feet thick, of which about one-half is occupied with the two lower divisions. It is safe, then, to assume that the five upper Survey divisions are above the Red Band. The upper three of these are remarkable for exhibiting sandy conditions like the Upper Limestone on parts of Stonebarrow; but they include only 13 feet, whereas the Upper Clay on the west face of Golden Cap is 30 feet thick, and the Upper Limestone should therefore be found towards the bottom of the fourth subdivision of the Survey Memoir, the base of which is 33 feet below the lowest Tier. The 'ferruginous band', the fifth subdivision, is probably a streak of stained clay, since it is 30 feet above where the Red Band should appear. The sixth subdivision contains no hard beds; and the seventh, of indurated marl and limestone, is admittedly 'occasional' and probably, therefore, local, but might be meant for the Red Band. This leaves the eighth and lowest subdivision, measured with the seventh as 54 feet thick. By measurement this bottom 54 feet should include both the Red Band and the Lower Limestone. The latter, presumably, is the "nodules of hard grey limestone", though there is nothing in the description that suggests that they are on one horizon; and the former the 'ferruginous bands', though, even where the Red Band appears to be double, this would be a poor description of that rock. Thus, even if this interpretation is right, it cannot be said that a satisfactory correlation has been established between the two accounts.

II. The Belemnite Marls.

The Belemnite Marls[3] consist of some 80 feet of rock, capped by the Belemnite Stone and bounded beneath by a limestone containing ammonites of the *armatus* group. The Survey assign the Marls to the zones of *armatus*, *jamesoni*, and *ibex*,[4] but do not suggest any lines of demarcation; on the contrary, they speak of "an inosculation of the zones".[5] Six subdivisions are given, however, based on the lithic characters of the beds. In practice it is not easy to be sure of these subdivisions, and the following are suggested as easier to recognize in the field (see Diagram III, p. 409): (1) a lower division, about 40 feet thick, of darker marls—the Lower Marls; (2) a middle division, about 23 feet thick, of paler marls—the Middle Marls; and

[1] This concerns the general shape of the Cretaceous base-line in this district, see Jukes-Browne, Proc. Dorset Nat. Hist. Club, vol. xviii, p. 176, 1897; and Geol. Mag., Dec. IV, Vol. V, p. 164, 1898.
[2] The most detailed account is in H. B. Woodward, op. cit., 1893, p. 69.
[3] The Stonebarrow or Belemnite Beds of the Survey Memoirs.
[4] H. B. Woodward, op. cit., 1893, p. 67.
[5] H. B. Woodward, op. cit., 1893, p. 68.

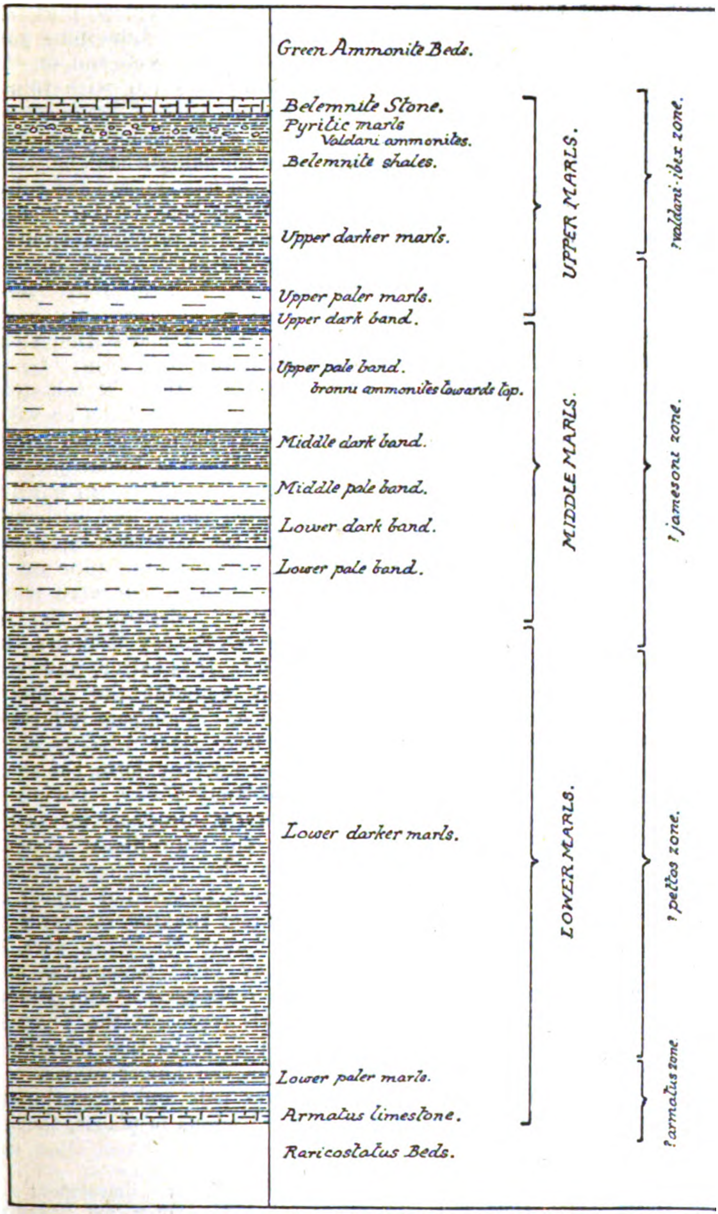


DIAGRAM III: DETAILED SECTION OF THE BELEMNITE MARLS.

(3) the Upper Marls, on the whole darker than the Middle Marls, about 16 feet thick.

The Lower Marls have at their base the Armatus Limestone just mentioned. This rock is rarely exposed on Black Ven and on the western end of Stonebarrow, being generally covered with talus; but it is well shown at the base of the eastern part of Stonebarrow Cliff where it comes down to the beach about a mile east of the mouth of the Char; and it forms a long ledge under the shingle bank between the tide-marks still further east, that is more or less exposed according to the accidents of wave and shingle. It is the home of the "large examples of this Ammonite [*Deroceras armatum*] with prominent spines" whose "particular horizon requires investigation" of the Survey Memoir.[1] The ammonites are poorly preserved, being represented only by a black film, and, since the matrix is comparatively hard, they are difficult to extract satisfactorily. The Armatus Limestone lies a foot or two above the Watch Ammonite Stone (the "Grey, earthy limestone" of the 1893 Memoir, and part of the "Watch-stone Beds" of the later Memoirs), a characteristic Limestone often crowded with Ammonites of the *raricostatus* group. At the base of the Lower Marls, and extending to within a foot of the Armatus Limestone, are one or two pale bands that look like Limestone. They can hardly, however, rank as such, being merely indurated marls, and, although highly calcareous, are quite soft compared with the Armatus Limestone. In fact, there is no definite bed from the Armatus Limestone up to the Belemnite Stone that is anything more than an indurated marl. If these are the "marly limestones and shales" constituting the last two subdivisions of the Belemnite Marls in the Survey Memoirs, the Armatus Limestone is not there recognized.[2] It is better, however, to regard these lowest two subdivisions as including the Armatus Limestone and the pale indurated marls above. These pale indurated marls at the base of the Lower Marls must have some wave-resisting quality in spite of their comparative softness, for they form the shoal called Hawkfish Ledge that lies just off Westhay Water. Owing to the change of the dip here from an easterly direction to nearly horizontal, this ledge, instead of running out seawards at a small angle with the coast, swings round festoon-wise, enclosing a minute roadstead at half-tide. The Armatus Limestone does not appear to form part of Hawkfish Ledge, but makes a reef running seawards of it. Except for the lowest few feet the Lower Marls are dark as a whole and comparatively barren. They yield belemnites and saurian remains, and, at the top, the same *Inoceramus* as the Middle Marls. If, as is possible, the Middle Marls represent the *jamesoni* zone, it is likely that the rare examples of *A. pettos* that have been found beneath Stonebarrow Cliff come from the Lower Marls.

The Middle Marls consist of three thicker pale and three thinner dark bands. The pale bands are very fossiliferous in places, though

[1] Woodward & Ussher, op. cit., 1911, p. 30.

[2] The Survey follow Day in calling these indurated marls, limestones; see Day, Quart. Journ. Geol. Soc., vol. xix, p. 281, 1863. On p. 280, however, Day speaks of "semi-indurated limestone", which is a far less misleading description.

the fossils for the most part are poorly preserved, and are not easy to find in place, however they may abound in fallen blocks. The commonest fossil is *Inoceramus falgeri*, Merian in Escher von der Linth,[1] a large form described from Lias above the Sinemurian of Lechthal, N.E. Switzerland. Several species of Ammonite have been found, but await identification. Since different horizons have yielded different kinds, it is hoped that if the species can be determined, it will be possible to draw zonal lines in this middle division with some exactness. Belemnites are common throughout. The bottom division—the Lower Pale Band—itself is sometimes divided by three still paler beds. It comes to the beach at Ridge Water, and owing to the reversal of the dip at this point rises on to the cliff on each side. It is thrice thrown down again on the east by the small step-faults already mentioned (p. 404) between Ridge Water and the big Ridge fault. The Middle Pale Band is easily recognized by being always divided by three paler beds and two intervening darker beds into five stripes. This feature is constant throughout the whole of its exposure from the western side of Black Ven to the Ridge fault; whereas the Lower Pale Band is only sometimes thus divided, and the Upper Pale Band, if differentiated at all, breaks up into a large number of beds. The Upper Pale Band is the thickest of the three, 8 feet as compared with 5 and 4 feet respectively for the Lower and Middle Pale Bands. It becomes somewhat darker in its upper part, and tends to pass into the Upper Dark Band. In its top portion it contains *Uptonia* aff. *bronni* (Roemer).[2] At about three-quarters of a mile east of the mouth of the Char, the Upper Pale Band is seen to split into about sixteen alternating lighter and darker stripes, but generally it is more or less uniformly pale.

The Upper Marls on the whole are dark. The bottom bed, however, a 2 ft. pale band, is conspicuously contrasted to the 1 ft. Upper Dark Band of the Middle Marls, and with it forms a convenient because easily recognized division between the Upper and Middle Marls. Above the 2 ft. pale band are 8 feet of darker marls, then 3 feet of dark Belemnite Shales, and finally 3 feet of marl with much pyrites capped with the Belemnite Stone. The 3 feet of Pyritic Marl are almost certainly the beds whence have come ammonites of the *valdani* group,[3] preserved in pyrites, that are not uncommonly found on the terrace below the Belemnite Marls. So far but one of these has been found by the author in place—1 foot below the Belemnite Stone. It is probable, then, that the line between the *jamesoni* and *ibex-valdani* zones will be drawn in the lower part

[1] A. Escher von der Linth, "Geol. Bemerkungen u. d. nördliche Vorarlberg und einige angrenzenden Gegenden," 1853, p. 1, pl. i, figs. 1–5. See also W. Ooster, in C. von Fischer-Ooster, "Protozoe Helvetica," vol. i, pt. ii, pl. xii, figs. 1–5, pp. 36, 37, 1869. I am indebted to my colleague, Mr. R. B. Newton, for kindly identifying this form.

[2] The following additional note was added by Mr. S. S. Buckman, who kindly identified this form: "?=young of d'Orbigny's large figure of *Uptonia regnardi*," d'Orbigny, 1842, Pal. Franç. Terr. Jur., p. 257, pl. lxxii, fig. 1.

[3] Mr. S. S. Buckman has kindly examined this form and identified it with *Acanthopleuroceras ellipticum* (James Sowerby), "very near to *A. valdani*."

of the Upper Marls. The Survey Memoir mentions "nodules and impersistent masses of hard grey limestone within two feet of [below] the Belemnite Stone".[1] At about this horizon, at Westhay Water, and forming a shelf at the top of the waterfall, is a lenticular bed of Limestone, 1 to 2 inches thick, largely composed of Crinoid remains.

The Belemnite Marls do not vary much in thickness, as a whole, from their appearance on the western shoulder of Black Ven to their disappearance beneath the beach east of the big Ridge fault; they vary a good deal, however, in the thickness and hardness of individual pale beds, which is probably due to the amount of segregation of calcium carbonate that has taken place; the thicker and paler the bed, the harder and more calcareous it appears. The limestones throughout the Charmouth Lias appear to be of the nature of segregations; the most complete having the form of nodules, like those of the *Stellaris* Beds[2] and the Lower Limestone of the Green Ammonite Beds[3]; the less complete being muddy limestones like those of the *bucklandi* zone (the *Birchii* Bed[2] is an example of a limestone now nodular, now tabular); the still less complete being indurated marls like those under discussion. Table Ledge[4] is a transition from an indurated marl to a muddy limestone.

East of the Ridge fault the Belemnite Stone rises to the foot of the cliff about a quarter of a mile east of St. Gabriel's Mouth, but soon plunges under the beach again, reappearing once more between Golden Cap and Seatown.[5] And the Upper Marls are exposed between the tide-marks under Golden Cap.[6]

It has been suggested that the Armatus Limestone and the indurated marls just above it are included in the two bottom beds of the six subdivisions made by the Survey in the Belemnite Marls. The third division from the bottom probably represents the rest of the Lower Marls, and the fourth division the Lower Pale Band of this paper. The fifth, then, would include the rest of the Middle Marls and all except the top 6 feet of the Upper Marls; and the top division, the Belemnite Shales and the Pyritic Marls. At any rate this correlation is more satisfactory than that attempted for the Green Ammonite Beds.

Finally, I would express my thanks, first to my wife for much help in the field; also to Mr. Thomas Hunter, fisherman, of Charmouth, who has known these cliffs from boyhood and helped E. C. H. Day who first worked them in detail, and for some years from time to time has given me much useful information and advice; and to Mr. L. Spath, F.G.S., for advice in connexion with the ammonites mentioned in the paper; as well as to Mr. S. S. Buckman, F.G.S., and Mr. R. B. Newton, F.G.S., whose help in each case has been indicated in the text of the paper.

[1] H. B. Woodward, op. cit., 1893, p. 68.
[2] H. B. Woodward, op. cit., 1893, p. 65, "*Am. stellaris* in nodules."
[3] See *ante*, pp. 401–2.
[4] H. B. Woodward, op. cit., 1893, p. 60.
[5] H. B. Woodward, op. cit., 1893, p. 52.
[6] H. B. Woodward, op. cit., 1893, p. 66.

V.—Notes on the Geology of the Bermuda Islands.

By Major A. J. Peile, R.A.

I.

In a very interesting article on the Geology of Bermuda, published in this Magazine for September and October, 1911 (pp. 385–95 and 433–42, Pls. XVIII–XXIII), the late Rev. R. Ashington Bullen states, on p. 390, that Admiral's Cave at Spanish Point is in the Walsingham Formation. This statement is evidently due to a slip in map-reading, Admiralty Cove being the boat harbour of Admiralty House near Spanish Point, whereas the Admiral's Cave, whence the *Pœcilozonites nelsoni* in the British Museum were derived, is the "cave near the calabash-tree" mentioned on p. 439. This cave owes its name to the visit of Admiral Milne, and the base of his stalagmite is still in evidence, bearing his tool marks. It is one of the largest and most remarkable of the many caves between Bailey's Bay and Tuckerstown.

With regard to the connexion between these shells and the formation in which they occur, *P. nelsoni* is found in great quantity, associated with a few other species, in a bed of earth far within the cave. It is probable that the earth was washed into the cave through some fissure when the rainfall in the islands was greater than it is at present. It is, however, noteworthy that the shells, which are well coated with a stalagmitic (?) deposit, do not as a rule contain earth. Traces of animal matter have been found in the inner whorls of some of them, and broken specimens often exhibit colour-bands resembling those of the living, but much smaller, *P. bermudensis* and its extinct variety, *P. zonatus*. In fact, the circumstances under which they are found here and in other caves[1] make it unlikely that the shells are contemporaneous with the rocks in which the caves are formed. *P. nelsoni* is also to be found in hard rock, and so are other species, some of which are extinct. In many cases the shells had evidently found their way into crannies in the rock, where they were later cemented in by stalagmitic deposits (*vide* diagram, p. 390). In other cases they appear to be regularly embedded in the mass of the limestone. It is probable that the variations in character of the æolian sandstone, due to chemical deposits from infiltered water, are not always an index of the age of the rock, so that it is just possible that the presence of these shells does not definitely determine a deposit as belonging to the Walsingham Formation, as suggested on p. 390.

It is interesting to note that the small neck of land between Castle Harbour and Harrington Sound, which is honeycombed with caves containing fossil shells, and which differs somewhat in the character of its vegetation from the rest of the islands,[2] is perhaps the only present habitat of two of the species of endemic snails that flourished along with *P. nelsoni*. These are *P. reinianus* and *P. goodei*. Living examples of these two species are hard to come by, but it is

[1] The first *P. nelsoni* recorded were found by Lieut. Nelson in a cave at Ireland Island, at the other end of the islands.

[2] It is sometimes said to be a bit of surviving jungle of the ancient Bermuda.

a suggestive fact that their dead shells may be found in large numbers in crannies in the rocks. The fossil specimens from some localities, but not from others, are larger than the living forms. Two other living species, *P. bermudensis* and *P. circumfirmatus*, are more widely distributed and are fairly common.

A most interesting account of the fossil land shells, by Professor Addison Gulick, is to be found in the Proceedings of the Academy of Natural Science of Philadelphia for July, 1904. There is still work to be done in the study of the varieties of fossil species from different localities and in tracing the connexion between the fossil and living forms.

II.

The analysis of the phosphorite rock, described at the end of the article, suggests an interesting problem. Flat bottoms among the reefs, at any rate in the more sheltered channels and sounds, consist of chalky mud, reduced to its present state in the intestines of the big holothurians, known locally as 'sea cucumbers'. It is possible that a similar origin for the rocks analysed would account for their coprolitic nature. The question of how such an ancient sea bottom came into its present position would still have to be tackled, but the theory now suggested seems at least more tenable than that of deep sea mud referred to as impossible on p. 440.

Although there is every proof that the islands have been sinking during past ages, there have been some slight upheavals, if only local, as evidenced by the so-called Devonshire formations containing marine shells (*vide* p. 393).

VI.—Note on a Buried (East Mercian)[1] River Channel near Peterborough.

By A. Irving, D.Sc., B.A.

In the *Peterborough Advertiser* for December 16, 1911, there appeared an illustrated article on a "recent discovery" of a silted-up pre-glacial river-valley, 250 yards wide, at Fletton, near Peterborough. Eliminating from that article a good deal of scientific romance, there remains a certain residuum of geological facts, so far as the determination of them by the writer of this note has been carried out, through the courtesy of Mr. A. Adams, the Manager of the London Brick Company's works.

The banks of the ancient river appear to be well defined on the north and south sides of the buried channel. Against these there lies a deposit of slimy river-silt derived from the material of the Oxford Clay, through which the river (comparable with the Trent at Newark) had carved out its course. This black silt contains fossils of the Oxford Clay itself, along with shells of *Cardium edule*[2], and

[1] Read at the British Association, Dundee Meeting (1912), Section C.

[2] Determined by Mr. R. B. Newton at the British Museum (Nat. Hist.). Mr. G. Wyman Abbott, of Peterborough, is preparing a paper on the shell-contents of these beds in co-operation with a well-known specialist on recent shells.

considerable masses of lignite, but apparently no boulders. It appears to be of local origin. Its junction with the Oxford Clay in situ is seen in open sections on both sides of the channel, while upwards it is mixed up with the fine stratified river-gravel and sand, which (as interglacial or 'subglacial'[1] deposits) seem by the evidence of well-sections to have filled the pre-glacial valley, as such deposits have filled the pre-glacial valley of the Stort.[2] In *composition* these gravels (so far as examined) agree remarkably with those at Stansted Mountfichet and other places in the upper Stort valley, and like them contain rolled Belemnites, Gryphæas, etc., from the Jurassic rocks. In other respects the gravels have also much in common with the high-level stratified gravels of the Trent at Beeston,[3] where the Jurassic fossils seem to be wanting. In open sections on both sides of the channel these gravels are, in their upper portions, puckered and distorted apparently by frozen masses of gravel of the floating-ice stage of glaciation, agreeing with the facts observed in the upper Stort valley[4] and in the old Windsor Forest country of the Thames outer valley[5] in East Berks.

The facts observed, as recorded in this and previous papers, taken together with the known physiography of the upper Trent basin, seem to suggest inferentially a connexion in late Tertiary times between that and the Thames Valley by way of the buried channel through the Chalk Range[6]; the capture of the Trent by the Humber being accounted for by crustal movements and by the glacial damming, of which the 90 feet of Boulder-clay furnishes evidence, as this was observed years ago by Dr. J. J. Harris Teall and myself, when the Midland Railway from Melton Mowbray to Nottingham was in process of construction. The River Nene above Peterborough appears to cut right across the buried channel, indicating the comparative modernity of the present river-system of the Wash Basin.

* * * * *

My more recent work during the month of August (availing myself of the local knowledge of Mr. G. Wyman Abbott of Peterborough) has led me to conclude—from observations made in the sand and gravel pits known as Anker's Pit and Rippon's Pit (both close to Peterborough) and in London Brick Company's Pit No. 1 at Old Fletton—that the relations of the Nene Valley to the ancient buried channel are not so simple as appears at first sight. In the silted-up Nene Valley, however, the succession of the deposits is roughly as follows:—[7]

[1] N. O. Holst.

[2] A. Irving, B.A. Reports for 1910, 1911.

[3] A. Irving, P.G.A., vol. xv, p. 232, 1898.

[4] Op. cit., vol. xv, pp. 224, 225. Also Report of Excursion to Bishop's Stortford (1911): op. cit., vol. xxii, pp. 264 ff.

[5] Op. cit.: Excursion to Wokingham and Wellington College in 1890, with photograph of one of the sections, now obliterated and overgrown. Similar photographs presented at the time to this Association, and one was published in *Science Gossip*.

[6] See B.A. Report, 1910 (Section C), p. 616.

[7] [Pre-glacial valleys in Northamptonshire have been described by Mr. Beeby Thompson, Journ. Northants Nat. Hist. Soc., ix, p. 47, 1896, and xii, p. 207, 1904.—Ed.]

ANKER'S PIT.

POST-GLACIAL SERIES	1. Gravelly loam. 2. False-bedded sand. 3. Stratified gravel. 4. Clay, 2 to 48 inches.
GLACIAL (PLEISTOCENE)	5. Gravel (late-glacial) and clay containing palæoliths and remains of horse and of *Elephas primigenius* with erratics. 6. Stratified gravel with erratics.
	7. Oxford Clay.

The deposits seen in Rippon's Pit may, I think, be taken as the equivalents of the upper three or four beds in Anker's Pit, while the lower series (5, 6) would seem to represent the succession in the pits of the London Brick Company, Nos. 1 and 4. There is much "contemporaneous erosion and filling-up"[1] in Rippon's Pit.

At No. 1 Pit (Old Fletton) the stratified fine sandy gravel is seen in open section extending down to the depth of 25 feet in the old channel and resting upon probably reconstructed Oxford Clay. Like the same gravels at No. 4 Pit, it contains erratics of considerable size, so that they would both seem to be sub-glacial, and to represent the 'ice-raft' stage of the later glaciation of the district. At both places they yield mammalian remains (including *E. primigenius*), and have the same character in structure and composition as that given above in detail for the No. 4 Pit. It is, however, a noteworthy fact that at the latter place they overlap the bank of the pre-glacial valley, with a deposit 8 or 9 feet thick, indicating the widespread shallow-water conditions of the later ice-raft stages of glaciation. That they are of later date than the great Chalky Boulder-clay is evident from the fact that a ridge of high ground some miles in length, to the south-east, consists of that deposit, in which I recognized erratics from the Chalk, the Lias, and the Carboniferous Limestone, when I visited it in company with Mr. Abbott, to whose courteous guidance over the district I am much indebted.

VII.—THE 'WEATHERING OUT' OF STRIATIONS UPON FLINT.

By J. REID MOIR, F.G.S.

FOR some time past I have had a difficulty in understanding how certain striated flints from various horizons stood, without breaking, the pressure to which they must have been subjected when such markings were imposed upon them. This difficulty increased when I found that thin flakes from the present land surface exhibited well-marked striæ, and as experiments with my presses had shown that even large flints will break up under no very great pressure, the possibility occurred to me of these scratches having altered since the flints were first subjected to the scratching process. I reasoned that if a point passed over a flint under pressure the area upon which the point impinged would be shattered, and that small plates or splinters of flint would be formed along the line of movement. I also concluded that, as with the thin plates which

[1] A term used long ago by F. B. Jukes.

are produced on a flint when flaking, and which are not found upon implements which have been exposed to atmospheric conditions, these fragments would in time, by thermal effects, 'weather out' and leave a clean-cut groove behind.

When I proceeded to test my theory by examining a series of striated flints in my collection I found various specimens which seem to me to show striæ in different stages of weathering. Thus one black glossy flint given me by Mr. E. St. H. Lingwood, of Westleton, Suffolk, and found by him on a ploughed field at that place, showed a shattered scratch extending for about 1½ inches across its surface. To prove that such a scratch could easily be deepened I attacked part of it with a steel probe and found that I could easily remove the thin plates of flint which were produced when the initial shattering took place. I then took a pointed flint flake and cleared away the remaining splinters of flint in the groove I had made, and this specimen, therefore, now exhibits a shattered line over half its length, and the other half a deepish groove.

This question of the 'weathering out' of scratches appears to me to be of some importance, because what we have looked upon as deep striæ caused by great pressure are in all probability merely 'weathered out' scratches, the initial stage of which would not require any very great pressure to produce. I give it as my opinion that every scratch imprinted upon a flint must have a shattered portion on the sides and floor of the scratch, and, further, this shattered portion, if exposed long enough to thermal effects, must 'weather out' and the scratch alter in depth and appearance until all the thin fragments are gone. If a flint gets striated, and then becomes covered by some impervious material such as clay, then it will be protected from thermal changes and no 'weathering out' of the scratches take place. This perhaps offers an explanation for the smallness of the striæ on the flints from the Chalky Boulder-clay, as compared with those showing on stones from below the Red Crag. The latter were scratched and then exposed on the pre-Crag land surface, and consequently got 'weathered out', while those in the Boulder-clay have been protected by the nature of the material in which they lie, and many of them exhibit typical unweathered out, shattered, scratches. In this note I refer solely to the striæ which are developed upon the hard portion of the flints, not to those upon the softer cortex.

NOTICES OF MEMOIRS.

Geological Survey of Southern Rhodesia.

THE following is an abridged statement from the Report of the Director, Mr. H. B. Maufe, for the year 1912 (fol.; Salisbury, Rhodesia, 1913): As a result of the detailed work amongst the metamorphic rocks, it is becoming increasingly clear that they are divisible into three series, one of which consists of three groups: (*a*) a greenstone schist group, including epidiorite, (*b*) a banded ironstone group, and (*c*) a conglomerate and grit group. The second series consists of ultra-basic rocks, some of which contain chromite and asbestos. The third series comprises a very variable group of fine-grained and frequently schistose acid rocks, which have not hitherto been recognized as a distinct series. Moreover, a consideration of the distribution of gold-bearing quartz reefs and the mode of occurrence of an important class of auriferous impregnations has led up to what is probably the point of greatest practical importance resulting from the year's work, namely, that the gold deposits of the Territory are closely associated with the last-named series of acid igneous rocks.

The north-western portion of the Wankie coal-field, including the main basin in which the colliery is situated, has been mapped by Mr. Lightfoot, whose geological work has determined the succession of rocks and the structure of this field. The discovery of fossil plants is interesting, as proving what perhaps was never seriously doubted by geologists, that the Wankie coal-beds belong to the lower part of the Karoo system. The main coal-seam is known to be a very thick one, and the best in the sub-continent for steam-raising purposes. The survey of the district now shows that the basin in which the colliery is situated, although bounded in parts by faults, is simple in structure, and remarkably free from faults and other disturbances. Estimates of the resources of the field made previous to the survey showed a very large reserve. Not only is this now confirmed, but a large addition may be made with considerable confidence. Mr. Lightfoot points out that probably 600,000,000 tons of coal could be taken out of the district mapped by him. Investigations were made, partly in conjunction with the Chemist to the Agricultural Department, into a number of deposits of limestone and clay, with special reference to their suitability for the manufacture of Portland cement; and a syndicate has proved by trial tests that such a cement, exceeding the requirements of the revised British standard specification in strength, etc., can be made out of materials occurring near Bulawayo, and that a sufficient quantity of them is available.

Observations on the relation of the soil, or more accurately the subsoil, to the underlying rocks have resulted in the collection of a considerable amount of evidence showing that the soils are largely residual accumulations, and that two of the most important factors in determining their character are (1) the nature of the underlying rocks, and (2) the behaviour of the soil-water.

REVIEWS.

I.—Caradocian Cystidea from Girvan. By F. A. Bather, M.A., D.Sc., F.R.S. Trans. Roy. Soc. Edinburgh, vol. xlix, pt. ii, No. 6. 4to; pp. 359–530, with 6 plates and 80 text-figures. Edinburgh: Robert Grant and Son, 107 Princes Street, 1913. Price 15*s*. 6*d*.

(PLATE XIII.)

If we examine the various members in almost any grade of the Animal Kingdom we shall meet with some so unlike, *superficially*, our conception of the type, as to cause us, at first sight, to doubt their right to a place in the phylum to which they have been assigned by the systematist. But a careful study of the larval stages of development of many such erratic forms has usually led to the recognition of their true position. It is within the memory of the writer that *Lepas anatifera* was arranged with the Mollusca in the Shell

Gallery of the British Museum, and, at a much later date, the Brachiopoda and the Tunicata (1851–6) were still retained in textbooks in the same phylum, as a part of the Malacostraca.

As palæozoologists we are much indebted to Dr. F. A. Bather for having undertaken the study of the Echinoderma, of which he says it is "one of the best characterized and most distinct Phyla of the Animal Kingdom". Notwithstanding this encouraging introduction, we venture to think that this division contains many very difficult organisms to investigate, to which the author has devoted long years of careful and diligent study and made extensive acquaintance with both the literature of the subject and the specimens to be described. Particularly we must thank him for that admirable volume in 1900 on the Echinoderma.[1] In it Dr. Bather writes: "Nearly all the living animals included in this phylum, such as the sea-urchin (Echinoid), starfish (Asteroid), brittle-star (Ophiuroid), sea-cucumber (Holothurian), and sea-lily (stalked Crinoid), or feather-star (free Crinoid), can readily be distinguished through their possession of a radial symmetry, in which the number five is dominant; of a sub-epidermic skeleton composed of calcium carbonate with a characteristic micro-structure resembling trellis-work, and of a system of sacs, canals, and tubes that carry water through the body, especially by means of five radial canals from which small branches called *podia* are given off to the exterior. The extinct forms known as Blastoidea and Edrioasteroidea appear to have had a similar organisation, and the same statement may be made of most of the Cystidea"—the class which forms the subject of the present monograph.

In this his latest work the author presents us with a description of the Cystidea (one of the three extinct and most aberrant classes of the Echinoderms), collected from the Caradoc Beds (Ordovician) of Girvan, Ayrshire, by Mrs. Robert Gray, who has done so much to add to our knowledge of the fossils of this now historic locality. In this undertaking she has been fortunate in having had the co-operation of various palæontologists, including the late Professor H. A. Nicholson, Mr. Robert Etheridge, jun., Mr. F. R. Cowper Reed, Dr. F. A. Bather, and others.

"Though written" (says Dr. Bather) "in order to describe Girvan material, the memoir has grown to be little less than a monograph of the genera dealt with, and even includes the description of a new species from Bohemia. For this no apology is required. When a group of organisms has recently received adequate revision, new forms may on occasion be merely described and referred to their systematic position. In the present instance, prolonged study of allied species and genera proved a necessary preliminary to the understanding of the Girvan fossils, and if the descriptions of the latter are to be intelligible the reader must first be placed at the same point of view as the writer."

To show the geological distribution in Girvan of all the Cystid remains, both described and undescribed, the author adapts a portion

[1] Contributed to Sir E. Ray Lankester's *Treatise of Zoology* (assisted by Dr. J. W. Gregory and E. S. Goodrich), 8vo, 1900, pt. iii, pp. viii+344, and 309 text-figures.

of the Table of Girvan Strata drawn up by Messrs. Peach, Horne, and Macconochie (1901).[1]

Llandovery—Newlands Series.	
3. Camregan Group. Grits, limestones, and shales. *Rastrites maximus.*	Bargany Pond Burn. Plate of a Glyptocystidean (?).
2. Saugh Hill Group. Flagstones and shales. *Monograptus spinigerus. Rastrites peregrinus.*	Woodland Point. One plate and one base (?) of a Cystid (?).
1. Mulloch Hill Group. Sandstones and shales; conglomerate. *Diplograptus acuminatus.*	
Caradocian—Ardmillan Series.	
5. Drummuck Group. Mudstones, Starfish Bed. *Dicellograptus anceps.*	Thraive Glen. Species of *Dendrocystis, Cothurnocystis, Cheirocrinus, Pleurocystis.*
4. Barren Flagstone Group. *Diplograptus truncatus.*	
3. Whitehouse Group. *Dicellograptus complanatus. Pleurograptus linearis.*	Shallock Mill. Plates suggestive of *Echinoencrinus.*
2. Ardwell Group. Flagstones and shales. *Climacograptus caudatus.*	
1. Balclatchie Group. Conglomerate, mudstones. *Climacograptus bicornis.*	Ardmillan; a Glyptocystid (? *Cheirocrinus*) and plates α and β. Balclatchie; plates β (γ = Glyptocystidean) and ϵ (= Echinosphærid). Dow Hill; plates δ and ϵ, plates of *Cheirocr.* (?), and fragments indett.

The Starfish Bed, as its name implies, is prolific in Echinoderms. In addition to *Tetraster Wyville-Thomsoni* there are many Asteroidea, now being studied by Mr. W. K. Spencer. Though the Cystidea of the Starfish Bed are numerous in individuals, the number of species is small. Dr. Bather describes only nine species, of which eight are new, and it is, he thinks, quite possible that some future palæontologist will say these are twice as many as they ought to be. The genera represented are—

Amphoridea Heterostelea—	Rhombifera—
Fam. Dendrocystidæ.	Super-fam. Glyptocystidæ.
Dendrocystis. 1 sp.	Fam. Cheirocrinidæ.
Fam. Cothurnocystidæ.	*Cheirocrinus.* 2 spp.
Cothurnocystis, n.g. 2 spp.	*Pleurocystis.* 4 spp.

The Amphoridea among the extinct Cystidea are defined by the author (p. 364) as "Primitive Cystidea in which radial symmetry has affected neither food-grooves, nor thecal plates, nor (probably) nerves, ambulacral vessels, nor gonads". In fact, they are most irregular forms of Echinoderma, and might well be styled as the 'Nonconformists' of their order, of which *Rhipidocystis* is an example

[1] "The Silurian Rocks in the South of Scotland" in *Fauna, Flora, and Geology of the Clyde Area*, Brit. Assoc. Glasgow, pp. 423–44.

(see p. 369, figs. 1–3, and p. 370, fig. 4) from the Ordovician of St. Petersburg. Here are also placed the species of *Dendrocystis*—

Described as having "a theca broader towards the column and composed of numerous plates irregular in size, form, and arrangement, the vent lateral and adcolumnal, the intake lateral and a-columnal and connected with a single skeletal process composed of four series of ossicles, with a stem proximally widening and composed of small widened ossicles, distally sub-cylindrical, gently tapering, and composed of elongate dimeres, and intermediately of transitional composition". (p. 369.)

We reproduce one example, namely, *Dendrocystis scotica*, Bather, sp. nov., Plate XIII, Fig. 3.

Altogether five species are enumerated, namely—

D. scotica, F. Bather, sp. nov. Upper Caradocian: Thraive Glen, Girvan. Op. cit., p. 374, fig. 9; p. 391, pl. ii, figs. 10–25.

D. Sedgwickii, J. Barrande. Zahorzan, Bohemia. Lower Caradocian: Girvan. Op. cit., p. 374, fig. 8; p. 387, pl. i, figs. 5–9.

D. paradoxica, E. Billings. Trenton Limestone: Quebec. Op. cit., p. 397, text-fig. 13; p. 396.

D. rossica, O. Jaekel. Upper Llandeilian: Esthland. Op. cit., p. 396, text-figs. 10–12.

D. Barrandei, F. A. Bather, sp. nov. Lower Llandeilian: Bohemia. Op. cit., p. 383, pl. i, figs. 1–4; p. 374, text-figs. 6, 7.

The next remarkable form from Girvan is referred to a new genus, *Cothurnocystis*, of which two species are named: *C. Elizæ*, F. A. Bather, gen. et sp. nov.,[1] and *C. curvata*,[2] F. A. Bather, sp. nov. Drummock Group, Starfish Bed: Thraive Glen, Girvan.

Cothurnocystis,[3] so named by the author from the outline of the frame being markedly boot-shaped, has its integumentary plates normally flat and tessellate, with subvective grooves of elliptical outline, occupying an area immediately adjacent and parallel to the curve of the boot sole (Plate XIII, Fig. 1).

On Plate XIII we give two figures, the obverse (Fig. 1) and reverse (Fig. 2) of one species, *C. Elizæ*, so named in honour of Mrs. Elizabeth Gray, to commemorate her zeal in collecting so rich a series, and her acumen in recognizing the peculiar shape and the Cystid nature of these extraordinary fossils. They were obtained from the Starfish Bed, Girvan. (p. 400.)

"This creature" (says Dr. Bather), "though plainly a Pelmatozoon, is so different in structure and outward form from any other Pelmatozoon as yet known that it is by no means easy to discover its true affinities. The very fact of this difference points to the conclusion that the animal was modified for some unusual habit of life; and our first task must be . . . to reconstruct from the dry bones the living organism." He then proceeds to describe the position of the *vent*, situated between two spines on the dorsal surface ("described as the leg of the boot"). "A vent of this nature implies a gut and a corresponding intake." (p. 413.)

After careful study and comparison with other forms, the author concludes that *Cothurnocystis* must have obtained its food by

[1] Op. cit., pp. 398–408, pl. iii, figs. 26–38, text-figs. 14–23.
[2] Op. cit., pp. 408–12, pl. iv, figs. 39–45, text-figs. 24–28.
[3] From κόθορνος (*cothurnus*), a high Grecian shoe, the foot-covering of tragic actors.

a subvective system of ciliated grooves,[1] and he shows that each of the elliptical organs was in part such a groove; that the rim is divided at about two-thirds the distance from its outer end into an inner *short* U and an outer *long* U, meeting by their free ends. The opening of the larger U was roofed in by an alternating series of movable cover-plates, and the opening of the short U was protected by its own bounding wall so as to form a hood which on occasion could meet the closed cover-plates, and so shut the whole opening. "Every known Echinoderm with a stem is a Pelmatozoon, and as such obtains its food by a subvective system of ciliated grooves, there is therefore no reason to suppose that in this respect *Cothurnocystis* was any exception. . . . When in full swing the cover-plates were open, the tentacles or podia were fully protruded, and a stream of sea-water was driven down each of the fifteen or more grooves, and diverted by the hood of the short U through the round mouth. Then if some passing animal brushed against a tentacle, the podia were quickly retracted, all the cover-plates shut down, and the hoods pulled up against them so as to close the mouths." (p. 415.)

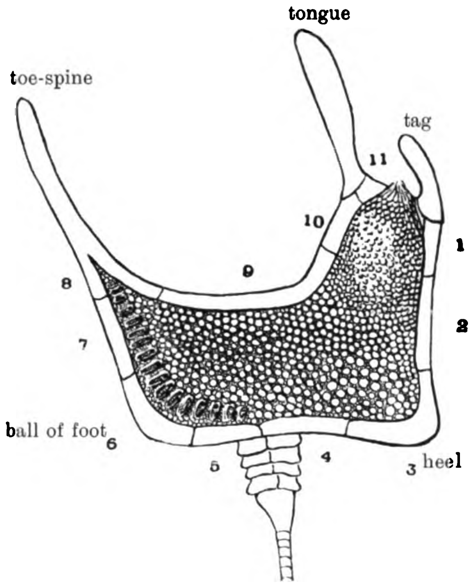
In what position did *Cothurnocystis* live? There is no trace of a root or of any means of attachment, and it is probable that the stem after gradually tapering was rounded off abruptly, and did not fix it in any way. The position of both intake and vent are on the *obverse* face; we may conclude, therefore, that the *reverse* face was directed towards the sea-floor. The extreme flattening and lateral extension of the theca lead to the conclusion that the whole skeleton lay flat on the sea-bottom. The knobs on the reverse side of the frame and the strut on that side served to give support to the flexible integument.

Remarkable as this form appears to be among the Cystidea, it is not alone, for *C. curvata* (save in the absence of the club-shaped spines upon its dorsal surface) is a near repetition of this prolate type (see text-figs. 24, 25, op. cit., p. 409), and *Ceratocystis Perneri*, Jaekel, from the Middle Cambrian of Bohemia, is also remarkable for its boot-like form (see p. 423, text-figs. 33, 34).

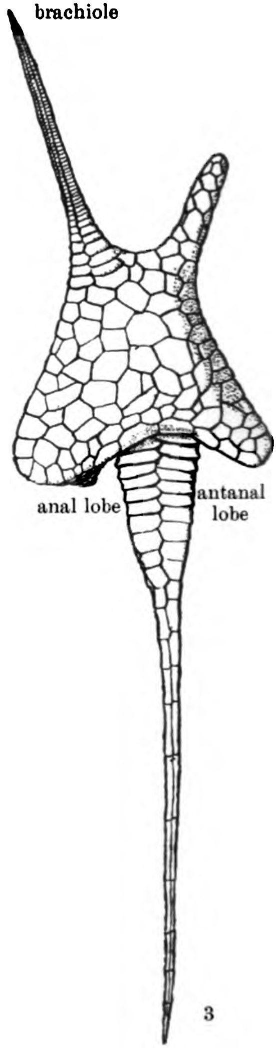
The Pelmatozoan life was a very simple existence: its members were mostly sedentary (if not always attached), receiving their food-particles along specially constructed food-grooves, subsisting, like their neighbours the Protozoa, Brachiopoda, Lamellibranchia, and Tunicata, on the currents made by their podia or cilia in the sea, which with its stream brought them the needful supply of aliment. Many of the more energetic members of the Eleutherozoa (the sea-urchin, starfish, and sea-cucumber) indulge in a predaceous and peripatetic existence, filling their stomachs with a selected and more attractive diet.

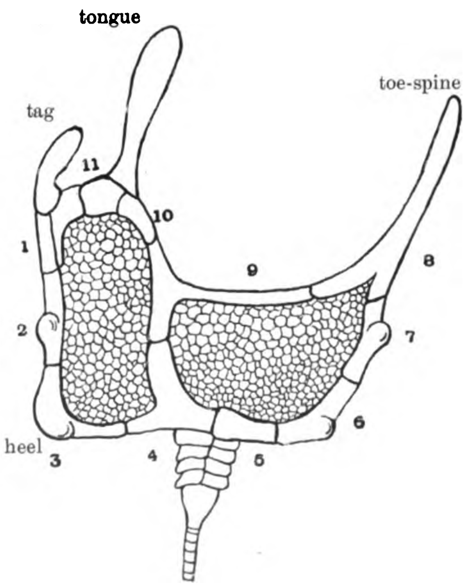
But we have already trespassed upon our allotted space, and can only refer to the ingenious explanation of the author (pp. 415–17) to show how *Colothurnus*, with the help of its short stalk, its flattened body, and its rigid frame, furnished with knobs and spines, sustained life by lying flat upon the sea-floor, and through all its vicissitudes always managed *to keep its right side up*.

[1] See Pl. XIII, Fig. 1 (a line of fifteen elliptical openings parallel to the marginal plates 5–7).



1. OBVERSE.





2. REVERSE.

3

1, 2, *Cothurnocystis Elizæ*. 3, *Dendrocystis scotica*.
Caradocian: Girvan, Ayrshire.

And now the reader must be left to follow the author through the 172 quarto pages of this most interesting monograph, so fully and finely illustrated. We have been permitted by Dr. Bather's kindness to reproduce three text-figures of two species from Girvan in our Plate XIII, which will show how divergent were these early forms of life among the Pelmatozoa.

H. W.

EXPLANATION OF PLATE XIII.

FIGS. 1, 2. *Cothurnocystis Elizæ*, Bather. Reconstructions of the two faces, based on the various specimens mentioned in the text. Probably no individual quite reached the size of these figures, though a few fragments come very near it. The numbers 1–11 refer to the marginals beside which they are placed. The proximal and median regions of the stem are drawn, with a few columnals of the distal region.

Fig. 1. The obverse face, showing the vent just below the number 11, the subvective system close to marginals 5–7, and the irregular rounded plates of the integument.

Fig. 2. The reverse face, showing the strut, the knobs on 2, 3, 6, 7, and the flattened plates of the integument.

FIG. 3. *Dendrocystis scotica*, Bather. Between the anal lobe and the stem the plates of the vent form a projection.

Both fossils are from the Starfish Bed in the Drummock Group, Thraive Glen, Girvan.

II.—THE WANDERINGS OF ANIMALS. By HANS GADOW. Cambridge Manuals of Science and Literature. Cambridge: University Press, 1913. Price 1*s*.

IN this little book of 150 pages Dr. Gadow has succeeded in giving a sketch of the distribution of animals which will be useful to students of geology and others seeking an introduction to this branch of science. Perhaps the most interesting chapter is that on the "Features of Environment", in which he describes the life of tropical forests, of deserts, and of high mountains as examples of contrasted habitats, and shows how these help or hinder the spreading of certain types of animals.

It is significant of the changed standpoint of modern zoogeography that the book does not contain one of the familiar maps showing the world divided into zoological 'regions'. Instead of it we have a series of maps, showing, in the first place, the actual distribution of certain selected groups of terrestrial vertebrates, and, in the second place, the changes in configuration of the great land masses in the successive geological epochs since the Trias. These latter maps, as Dr. Gadow is careful to explain, are to be regarded as tentative and hypothetical; "they will be objected to by the timid, on principle; critics with more expert knowledge will amend them." Of course, in a work of so wide a scope, inaccuracies in detail are likely to be discovered here and there by the specialist. There is no trustworthy evidence for the occurrence of crayfishes in Fiji or Melanesia (p. 92), or for the statement that "some existing species" of Scorpions "date back to the Coal-measures" (p. 93). Dr. Gadow's vigorous, though not always very careful, style has betrayed him on p. 15 into the assertion that "the search for generally applicable regions is a mare's nest"!

III.—Photographic Supplement to Stanford's Geological Atlas of Great Britain and Ireland. Arranged and edited by H. B. Woodward, F.R.S., with the co-operation of Miss H. D. Sharpe. 8vo; pp. 113, with 108 plates. London: Edward Stanford, Ltd., 1913. Price 4*s*. net.

A WARM welcome is assured to this supplement to the *Geological Atlas*. The editor, collecting his material from numerous sources, has selected 108 photographs of the most typical sections in the British Isles. Great care has been exercised in the choice of negatives, and the printing is good. The photographs are reproduced as half-page plates, each being accompanied by a brief explanatory notice with references to original publications and to the maps in the *Geological Atlas*. The arrangement is as far as possible chronological, and there is a good index of formations, localities, and authors, so that the book is one of ready reference.

IV.—Figure Stones.

On Palæolithic Figures of Flint found in the Old River Alluvia of England and France, and called Figure Stones. By W. M. Newton, F.R. Anthrop. Inst. Reprinted from the Journal of the British Archæological Association, March, 1913. 8vo. London: at the Bedford Press.

THE fantastic forms assumed by flints in the Chalk are familiar to everyone who has visited sections in the upper strata of that formation, and forms suggestive of many different kinds of animals—birds, beasts, reptiles, and fishes—have been rudely modelled by Nature. These have sometimes been actually taken to represent the creatures themselves in a fossilized condition, as in the "Facts and Fossils adduced to prove the Deluge of Noah", by Major-General Twemlow (see Geol. Mag. for 1869, p. 81). In other geological formations nodules of ironstone and argillaceous limestone sometimes assume forms suggestive of different animals, as in the concretions of the Champlain Clays of the Connecticut Valley, described by Mr. J. M. A. Sheldon (see *Nature*, April 11, 1901).

The specimens to which Mr. Newton directs special attention have been obtained by him and by workmen in his employ from a gravel-pit at Dartford in Kent, and they consist of flint-stones that have probably in all cases been naturally derived from the Chalk and embedded in the ancient valley gravel. At the same time it is not impossible that Palæolithic Man might have picked up some flints from the talus of a chalk cliff.

Forms described and figured by Mr. Newton have rude resemblances to fishes, birds, a tortoise, deer, horse, rhinoceros, elephant, etc., but he does not as a rule suggest any definite identification. The allegation is that these and other stones attracted the attention of Palæolithic Man, that he recognized a rude sort of animal form, and touched up the stones, where he could improve the resemblance, by chipping cavities for eyes, nose, or mouth, and in other ways slightly modifying the natural shape of the flints. There is nothing absurd or impossible in the suggestion. The pictorial engravings of various animals on stone, bone, horn, and ivory, from cavern deposits of Palæolithic age, are well known, and figure stones have been regarded as "first attempts at sculpture by Prehistoric Man". In considering the subject it is especially interesting to know that Boucher de Perthes in 1849 had figured flints suggestive of animal forms, and later on in 1861 (as pointed out by Mr. Newton) he drew attention to the importance of observing whether the stones had been notched or otherwise chipped so as to indicate the handiwork of man.

It was early in 1902 that Mr. Newton discovered his first figure stone from the Dartford gravel. The deposit there is about 18 feet thick and about 65 feet above O.D., and Mr. Newton obtained permission to collect any curious stones and to receive the aid of the workmen in putting aside similar specimens. At the end of the year the pit would have been closed, but as "such remarkable examples of figure stones with intentional work upon them" had been obtained, Mr. Newton arranged to work the pit at his own expense, and for a further period of five years some 5,000 tons of gravel were excavated and examined. He remarks that "At an early period of my enquiry it became evident that I had chanced upon the site of a Palæolithic settlement of great antiquity—implements, cup-stones with worked rims, rings of flint, anvils (so-called), and many curious shapes in worked flint made their appearance; among the latter the forms of animal heads predominated, the cups taking next place in point of numbers, implements [occurring] in very small quantity considering the vast amount of gravel excavated". At Swanscombe, on the other hand, the gravels have yielded numerous implements but very few cup-stones, and rarely a figure stone. Thus Mr. Newton points to the two settlements as affording evidence of distinct industries. It is indeed remarkable that the figure stones should be thus locally abundant, a fact which supports the view that many were intentionally gathered together by man.

The careful particulars given by the author, and his impartial explanation of them, deserve all consideration.

V.—Phosphates of Egypt.

Topography and Geology of the Phosphate District of Safaga (Eastern Desert of Egypt). By John Ball, D.Sc., F.G.S., Ministry of Finance. Survey Department, Egypt. Paper No. 29. Cairo, 1913.

SAFAGA is a small district on the Red Sea just to the south of the Gulf of Suez. The phosphate deposits occur on either side of the Wadi at distances of from 12 to 22 kilometres inland. The Um-el-Huetat mines are connected by railway with the port, and the climate is said to be extremely healthy. The geology consists of Alluvial beds, Eocene limestones, etc., Upper Cretaceous limestones and marls, Phosphate beds and cherts, also of Upper Cretaceous age, Nubian sandstones, and Crystalline rocks. Fossils are scarce, but "the beds are doubtless of Danian age". Maps, sections, and views accompany the paper, which concludes with a complete list of all publications issued by the Survey Department up to date.

"A Brief Note on the Phosphate Deposits of Egypt," by Dr. John Ball, has also been published as Survey Department Paper No. 30 (Cairo, 1913). The author calls attention to the extensive beds of phosphate of lime which occur in various parts of the deserts of Central Egypt, in sedimentary strata belonging to the Upper Cretaceous system. Their commercial value was pointed out by the Geological Survey in 1900, and it is highly satisfactory to learn that while the output in 1908 was 700 tons, and in 1911 as much as 6,425 tons, in 1912 it was 69,958 tons.

VI.—Department of Mines, Canada.

We have received vols. v and vi, which complete "An Investigation of the Coals of Canada with reference to their Economic Qualities", by Messrs J. B. Porter and R. J. Durley (1912).

We have also received a work entitled "Tourbe et Lignite, leur Fabrication et leurs Emplois en Europe", by Mr. E. Nystrom (1913). In this volume the author gives the results of a personal study of the industries connected with peat and lignite (or Brown Coal) in various parts of Northern Europe, the object being to aid the development of the peat industry in Canada. The methods and processes of working peat were examined in Sweden, Norway, Finland, Russia, Denmark, Holland, and Austria; and of peat and lignite in Germany. The volume is mainly of technical interest; the author gives a brief account of the classification and composition of peat, and then passes on to practical matters, giving detailed accounts of his observations, with illustrative plates and text-figures of implements and machines employed in the cutting of peat and in its fabrication into various forms of fuel. There are views of the excavations, of blocks and stacks of peat, and of methods of transport. Accounts are also given of the uses of peat for moss-litter and other economic purposes.

We have further received the Annual Report on the Mineral Production of Canada for the year 1911 (1913), by Mr. John McLeish. The chief products are copper, gold, iron, lead, nickel, silver, asbestos, coal, gypsum, petroleum, pyrites, quartz, and salt.

VII.—The Magnetic Iron Sands of Natashkwan, County of Saguenay, Province of Quebec. By G. C. Mackenzie. 1912.

This has been published as a separate report. The Iron Sands consist chiefly of quartz, felspar, garnet, olivine, magnetite, and ilmenite, and they occur on the north shore of the lower St. Lawrence river and gulf. The deposits vary much in extent and thickness, and they appear worthy of practical attention in not more than three or four localities. To be of commercial value it is necessary to separate not only the magnetite and ilmenite from the other minerals, but also the major part of the ilmenite from the magnetite. Only one serious attempt has been made to concentrate and smelt the magnetite. This was at Moisie, about 330 miles east of Quebec City; but the works have been closed. It is pointed out that the Natashkwan sands constitute one of the most promising of the deposits, as there is a treeless dune area which "contains at least 500,000 tons of magnetic iron concentrate that will average 67 per cent in iron".

VIII.—Brief Notices.

1. Permo-Carboniferous Ice Age in Western Australia.—This subject was dealt with by Mr. A. Gibb Maitland in his Anniversary Address to the Natural History and Science Society of Western Australia (vol. iv, session 1910–11). The essay is well illustrated by map, sections, and photographic views.

2. Geological Survey of South Australia.—In, Bulletin No. 2 (1913), the Government Geologist, Mr. L. Keith Ward, discusses the possibilities of the discovery of petroleum on Kangaroo Island and the western coast of Eyre's Peninsula, and comes to the conclusion that the facts do not justify the expenditure of capital in boring for oil. Some account is given of the rubber-like material known as 'coorongite', but there appears to be no genetic connexion between it and petroleum.

3. Mining in South Australia.—The *Review of Mining Operations* in the State during the half-year ended December 31, 1912 (No. 17, 1913), gives satisfactory accounts of the production of copper, gold, and silver; other minerals obtained include lead and iron ores, uranium ores, gypsum, and graphite.

4. Indian Aerolites.—G. de P. Cotter, B.A., contributes "Notes on Indian Aerolites recorded since 1906" (Rec. Geol. Surv. India, vol. xlii, pt. iv, p. 265). The paper gives details of six falls, viz., Vishnupur, Chainpur, Mirzapur, Baroti, Khohar, and Lakangaon. It is admirably illustrated by fourteen photographs of separate stones, and by a map of the Chainpur fall. The mineral constitution of the stones is only discussed very briefly.

5. The Bernese Jura.—The structure of the Bernese Jura finds an able expositor in Dr. P. Schlee, who in an interesting paper published in the Mitth. geogr. Gesellsch. Hamburg, xxvii, 1913, illustrates his remarks with a fine series of photographic reproductions, a map, and sections. The paper can be obtained separately from Friederichsen & Co., Hamburg, for 3 marks.

6. Termites and Geology. — Mr. Donald Steel writes in the *American Naturalist*, July, 1913, on this subject. He does little more than record the facts, but we gather from a perusal of his paper that the work of the Termites is much like that of worms, a turning over the surface soil. The Termite, however, piles the soil up into hillocks, which are themselves worn down again by storms, and gradually spread over the surrounding country.

7. The Landes of Gascogny.—M. Edouard Harlé (Bull. Soc. géol. France (4), xii, 1912) has investigated the Landes of Gascogny, and comes to the conclusion that far from being extremely old and entitled to the term 'Pénéplaine landaise' of authors, these tracts are quite modern and still in process of formation. They are due to the prevalent westerly winds, are of different ages, and continually changing. In the same communication Harlé traces the changes in the bed of the River Adour, the struggle between that river and the dunes, and their influences on each other.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 25, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

Mr. C. Dawson, F.S.A., F.G.S., exhibited zinc-blende occurring in ironstone nodules which contain plant-remains, in the celebrated plant-bed of the Fairlight Clays, Fairlight, near Hastings. He remarked that the form is crystalline and the ore is frequently found filling up cavities left by the decayed vegetable matter. Zinc-blende is not known to occur at other horizons in the Weald, nor anywhere else in the South-East of England. It is probably segregated from older rocks of which the Wealden strata are composed.

He also exhibited pisolitic limonite, which occurs in considerable quantities at one or two horizons in the Fairlight Clays, near Hastings. On the shore at Pett Level, near Fairlight Cliff end, a very large deposit is found, just above the ordinary high-water mark. The deposit consists of minute spherical grains or nodules of sand-like condition. These, on being analysed, prove to contain 60 per cent of iron-oxide. In the cliff the iron-ore occurs in bands, the grains of which it is composed forming a compact grey conglomerate that turns dark brown on exposure. Many pieces of the conglomerate are to be found on the shore in a rolled condition. When disintegrated, they are deposited by the joint action of the eastward drift of the tide and the south-westerly wind along the shore. The deposit last year measured about half a mile in length, by about 30 or 40 yards in width, and was 3 to 4 feet deep.

The following communication was read:—

"The Miocene Beds of the Victoria Nyanza and the Geology of the Country between the Lake and the Kisii Highlands." By Felix Oswald, D.Sc., B.A., F.G.S.; with Appendices on the Vertebrate Remains, by Charles William Andrews, D.Sc., F.R.S.; on the Non-Marine Mollusca, by Richard Bullen Newton, F.G.S.; and on the Plant-remains, by Miss N. Bancroft, B.Sc., F.L.S.

The Miocene beds of the eastern coast of the Victoria Nyanza, south-east of Karungu, form a narrow zone (covered with black earth) at the foot of cliffs of overlying nepheline-basalt, and are only exposed in a few gullies. The whole series is conformable, dipping 8° north by west.

1. Beds 1–12. An upper group, about 70 feet thick, of grey and brown clays and shales, with occasional current-bedded sandstones containing terrestrial shells (*Tropidophora*, *Cerastus*), as also calcified tree-stems in the uppermost bed.

2. Beds 13–25. A middle group, about 30 feet thick, of red and grey clays, with white sandstones in the lower half. No bone-bed, but fragmentary Chelonian and Crocodilian remains occur sparsely throughout the series. Persistent horizons are a travertinous marlstone (No. 14) containing *Ampullaria* and *Lanistes*; a thin sandstone (No. 16) yielding Hyracoid jawbones; and a gravel (No. 24) yielding teeth of *Dinotherium*, *Protopterus*, crocodile, etc.

3. Beds 26–37. A lower group, about 35 feet thick, of current-bedded sandstones and gravels passing down into clays and marlstones. A conglomerate of calcareous nodules overlies gravelly sandstones (No. 31) containing isolated bones of *Dinotherium*, Anthracotheroids, rhinoceros, giant tortoises, etc., indicating a Lower Miocene (Burdigalian) age, with *Ampullaria*, *Cleopatra*, and terrestrial shells (*Cerastus*).

These fluviatile sediments were deposited in a lagoon, and were derived from gneisses, andesites, and quartzites that still occur in situ to the eastward. Calcareous springs acted intermittently, and the sediments became finer and less fossiliferous as the river-system reached its base-level.

The series overlies gneisses and amphibolites, with a north-north-westerly and south-south-easterly strike. In searching for the extension of these beds the author found them to be completely denuded on the south, while on the north they disappear beneath the basalt-plateau. Marching up the Kuja Valley, he found the upper beds lying on old andesite 15 miles inland, on the line of strike. Evidence is adduced of the lake having stood about 330 feet above its present level, and of a rejuvenation of the rivers since the formation of a gneissic peneplain, above which the Kisii Highlands rise in steep escarpments of ripple-marked, unfossiliferous, quartzitic sandstones, probably Devonian, separated from the underlying gneisses and schists by an extensive dolerite-sill. From Kisii the peneplain was traversed to the region of nepheline lavas near Homa Bay. Lake Simbi, an explosion-crater, was investigated; and a Pliocene series was found north of Homa Mountain.

The vertebrate remains described by Dr. C. W. Andrews include Proboscidea, Hyracoidea, Artiodactyla, Rodentia, and Reptilia, and fully support the suggested occurrence of Lower Miocene deposits on the shores of the Victoria Nyanza. A deposit of probably Pliocene age yielded a new (?) species of *Elephas*, also bones of antelopes and baboons.

The non-marine Mollusca associated with the Miocene vertebrates are freshwater and terrestrial shells which all belong to existing species. Only *Ampullaria*, however, still occurs in the Victoria Nyanza, while *Lanistes carinatus* is not found nearer than the Tana River, and the nearest recorded locality for *Cleopatra bulimoides* is in the Lake Rudolf region and Mombasa. Among the terrestrial shells, *Burtoa* is the sole genus occurring near the Victoria Nyanza; the other forms (*Cerastus*, *Tropidophora*, *Achatina*) are found at considerable distances therefrom. The total absence of Pelecypoda is also interesting.

On Wednesday, June 18, 1913, a Conversazione, at which about three hundred ladies and gentlemen were present, was held in the Society's apartments, from 9 to 11.30 p.m. In the course of the evening, lectures, illustrated by lantern-slides, were delivered by Professor W. W. Watts, F.R.S., on "The Buried Landscape of Charnwood Forest", and by Captain H. G. Lyons, F.R.S., on "The Marshes of the Upper Nile", and many interesting exhibits were shown.

The next meeting of the Society will be held on Wednesday, November 5, 1913.

CORRESPONDENCE.

MICRASTER PRÆCURSOR, ROWE.

SIR,—Your reviewer of *The Stratigraphy of the Chalk of Hants* in the March GEOL. MAG., 1913, pp. 122–3, seems to have misunderstood my remarks on this species; at any rate, the views from which he appears to be dissenting are not views advocated or held by me. I should therefore like to restate the points I intended to raise.

In the first place it appears to me that Dr. Rowe's monograph in effect established that every individual of the species *M. præcursor* possesses two sets of characters, which have practically nothing in common. The first set embraces a large number of characters which the individual shares with all specimens, not only of *M. præcursor*, but also of *M. cor-testudinarium* (and sometimes other species also) from the same horizon; these characters are therefore of great zonal value, but no specific value. The second set embraces a small number of characters which enable *M. præcursor* to be distinguished from its nearest ally, *M. cor-testudinarium*. As neither of these species is confined to a single zone, this second set of characters are not strictly of any *zonal* value; i.e., a record of *M. præcursor* does not identify the zone, but it only tells you that you are in one of two or (under Dr. Rowe's zonal classification) three zones. To put it briefly, the assemblage of individuals defined as the species *M. præcursor* has no zonal value; the individuals have, through characters which are not specific, great zonal value. (I did not expressly affirm the latter proposition because I regarded it as established beyond dispute; but your reviewer seems to have failed to perceive that the two propositions are quite independent, and to have assumed that a challenge of the general view on one must necessarily be a challenge of the general view on the other.)

Secondly, on examining the characters by which *M. præcursor* is to be distinguished from *M. cor-testudinarium* they appear to consist substantially of shape variations in a particular direction, that of the proportion between length and breadth, with concurrent variations in minor features necessarily affected by variation in general shape. That is to say, the species *M. præcursor* is based almost entirely upon shape variations, while the prime object of Dr. Rowe's monograph was to prove that shape variations were not a valid basis for species of *Micraster*. This seems to indicate that *M. præcursor* is not specifically separable from *M. cor-testudinarium* as defined by Dr. Rowe, but that they are two sections of a single species which obviously must be known as *M. cor-testudinarium*, and that *præcursor* should be suppressed as a specific name. This does not in the least prejudice the zonal value of the individuals hitherto comprised in the species *M. præcursor*.

Thirdly, it is legitimate to inquire whether the *præcursor* section of the species *M. cor-testudinarium* is a natural one, for which '*præcursor*' can usefully be retained as a varietal or other subsidiary name. It seems to me that if it is a natural section, the dividing-line employed by Dr. Rowe ought to occupy the lowest, or nearly the lowest, point in a curve of frequency plotted for the various proportions between length and breadth in a large and representative series. I very much doubt whether this would be found to be the case.

Your reviewer tends to beg these questions by treating of the "*group of Micraster præcursor*". This phrase would, of course, be a well-recognized one to denote several allied species, among which *M. præcursor* is prominent. That may be the sense in which he uses it, but probably it is not so, for in that case his criticism would not be relevant to my remarks, as I only challenged one species, not several. I suspect that the phrase is current, and was used by your reviewer, to designate just the assemblage which Dr. Rowe named *M. præcursor*; and that the vague word 'group' has been added to a term which can only legitimately denote a species owing to a sub-conscious feeling that the assemblage in question is not satisfactory as a species. If so, the use of this expression tends to confirm my views; but in any case it is in itself so ambiguous that its use without a definition of its scope, for the time being, is to be deprecated.

R. M. BRYDONE.

27 TWYFORD MANSIONS, W.
August 16, 1913.

THE DIVISION OF THE UPPER CHALK.

SIR,—With respect to the scientific points raised by Mr. Brydone, they have really little to do with the division of the Upper Chalk into two stages. He only concerns himself with the line of division between his two zones of *Offaster pilula* and *Actinocamax quadratus*. The main question is this—suppose French geologists are right in believing that there are two faunas of stage-value in the comprehensive Senonian of d'Orbigny, where do we find the most convenient plane of division between them? At present they draw the line at the top of the zone of *Marsupites*; I gave reasons for drawing it at the top of a higher zone, that of *Placenticeras bidorsatum* and *Inoceramus lingua*, which though recognized has not yet been fully examined and defined in France.

This latter zone must be more or less coextensive with Mr. Brydone's zone of *Offaster pilula*, and if he can substantiate his zone and his upper limit of it throughout the South of England, it should also be applicable to the Paris Basin, and may eventually become the plane of division between a restricted Senonian and a Campanian stage, as suggested by me last year: that is the real point which requires further investigation.

Meanwhile I am quite prepared to agree with Mr. Brydone that the Yorkshire Upper Chalk is so decidedly North German in its affinities that its nomenclature should be North German rather than Anglo-Parisian. Let the discussion of the subject be limited at present to the Anglo-Parisian region, but here a caveat must be entered. It is well known that the species which go by the names of *A. granulatus* and *A. quadratus* are connected by a number of intermediate forms, and that Mr. Rowe regards the one as the lineal ancestor of the other. Mr. Brydone will have to define exactly what he means by *A. quadratus* and what he regards as the distinction between the two species, for it may be that his *A. quadratus* is not exactly what Mr. Rowe has taken to be the typical form of that species. The latter informs me that he never found anything really approaching his idea of *A. quadratus* in Sussex. Mr. Brydone may have been more fortunate, but on the other hand it may be that his finds would be regarded by Mr. Rowe as extreme forms of *A. granulatus*.

A. J. Jukes-Browne.

Torquay.
August 6.

OBITUARY.

PROFESSOR JOHN MILNE,

D.Sc., F.R.S., F.G.S., Hon. Fellow of King's College, London.

Born December 30, 1850. Died July 31, 1913.

It was only in August,[1] 1912, that we published in our list of Eminent Living Geologists a notice of the life and work of our dear friend John Milne. This August we received from Shide the sad news of his decease in his 63rd year. There is little to add to the record we published a short year ago. Seismographic stations extend over nearly the whole globe. Each station owes its inception to Professor Milne. The records which are maintained by his seismographs at Shide are automatically carried on as if he was still there; and after the meeting of the British Association in September it will be decided where and by whom the work shall be continued as a permanence. Such splendid observations cannot be allowed to lapse, for they interest not one country but every land and every nation. The work Professor Milne has given to the world cannot be permitted to die.

MISCELLANEOUS.

Mr. F. P. Kendall, jun., assistant curator of the Zoological Museum of the University of Sheffield, and son of Professor Kendall, of Leeds University, has been appointed lecturer in zoology and geology in the South-Eastern Agricultural College at Wye.

Mr. W. G. Fearnsides, M.A., F.G.S., Fellow and lecturer in Natural Sciences at Sidney Sussex College, and demonstrator in petrology in the University of Cambridge, has been appointed to the Sorby Chair of Geology at Sheffield.

Trustees of the British Museum.—Sir Archibald Geikie, K.C.B., Pres. R.S. (late an ex-officio Trustee of the British Museum), was elected on June 2 a member of the Standing Committee of that body in place of the late Lord Avebury.

Professor J. W. Judd, C.B., LL.D., F.R.S., has been elected by the Council Emeritus Professor of Geology in the Imperial College of Science and Technology.

[1] See Geol. Mag., August, 1912, pp. 337–46.

Fig. 1.

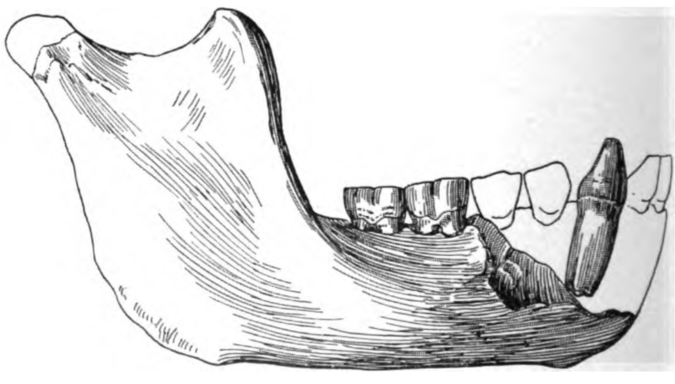


Fig. 2.

Eoanthropus Dawsoni, A. S. Woodw.

Pleistocene gravel, near Piltdown Common, Fletching, Sussex.

G. M. Woodward del.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. X.—OCTOBER, 1913.

ORIGINAL ARTICLES.

I.—Note on the Piltdown Man (*Eoanthropus Dawsoni*).

By A. Smith Woodward, LL.D., F.R.S., Keeper, Geological Department, British Museum (Natural History).[1]

(PLATE XV.)

IN a communication to the International Medical Congress recently reported in some of the English newspapers, Professor Arthur Keith expressed complete disapproval of my reconstruction of the skull and mandible of *Eoanthropus Dawsoni*.[2] I concluded that the brain capacity of this skull was comparable only with that of some of the lowest existing savages, while the mandible must have been provided in front with teeth of the ape pattern. Professor Keith, on the other hand, has restored the skull in such a manner as to have a brain capacity of 1,500 cubic centimetres, thus exceeding that of the average modern European. By distorting the curve of the front of the mandible he has also furnished it with completely human teeth. These two views, therefore, need careful examination before any definite conclusions can be drawn from this remarkable fossil.

Fortunately, Mr. Dawson has continued his diggings at Piltdown during the past summer, and on August 30 Father P. Teilhard, who was working with him, picked up the canine tooth which obviously belongs to the half of the mandible originally discovered. In shape it corresponds exactly with that of an ape, and its worn face shows that it worked upon the upper canine in the true ape fashion. It only differs from the canine of my published restoration in being slightly smaller, more pointed, and a little more upright in the mouth. Hence we have now definite proof that the front teeth of *Eoanthropus* resembled those of an ape, and my original determination is justified.

It may next be questioned whether this ape-like mandible belongs to the skull. We can only state that its molar teeth are typically human, its muscle-markings are such as might be expected, and it was found in the gravel near to the skull. The probabilities are

[1] Abridged from a lecture delivered to the British Association, Birmingham, September 16, 1913.

[2] C. Dawson & A. S. Woodward, "On the Discovery of a Palæolithic Skull and Mandible in a Flint-bearing Gravel overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex)," Quart. Journ. Geol. Soc., vol. lxix, pp. 124–39, pls. xviii–xx, 1913.

therefore in favour of its natural association. If so, it is reasonable to suppose that the skull will prove to be that of a very primitive type, not that of a highly civilized man. I have accordingly made a new study of the specimen, with the special help of my colleague, Mr. W. P. Pycraft, and I find that the only alteration necessary in my original model (made by Mr. Frank O. Barlow) is a very slight displacement of the occipital and right parietal bones, which Professor Elliot Smith pointed out to me when he made his first studies of the brain. Both behind and in front I correctly identified the internal groove for the upper longitudinal blood-sinus, which marks the middle line of the roof of the skull; and the reason why my adjustment of the occiput was not exact at first is, that on the hinder part of the parietal region of the skull-roof I noticed a longitudinal ridge which I supposed to be truly median, while the extraordinarily unsymmetrical development of the brain seemed to have pushed the longitudinal sinus at that part slightly out of its normal place. I now know that the longitudinal ridge is one of a pair. The change, however, only opens the upper part of the skull behind to an extent of three-quarters of an inch, and there are compensations elsewhere through the necessary readjustments, so the total brain capacity remains nearly the same as that I originally stated, well within the range of the smallest human brains of the present day.

I may add that I have submitted the new brain-cast to Professor Elliot Smith, who allows me to state that he finds it in all essential respects correct. He will shortly describe it in a memoir on fossil human brains to be read before the Royal Society.

EXPLANATION OF PLATE XV.

EOANTHROPUS DAWSONI, A. S. Woodw.; from a Pleistocene gravel near Piltdown Common, Fletching, Sussex.

FIG. 1. Right side-view of skull and mandible. One-third nat. size.

,, 2. Outer view of right mandibular ramus, with the canine tooth placed in natural position. Two-thirds nat. size.

II.—"THE ORIGIN OF MOUNTAINS": A REPLY.

By the Rev. O. FISHER, M.A., F.G.S.

I AM content to leave to the readers of the GEOLOGICAL MAGAZINE the question whether Colonel Burrard's theory of the elevation of mountains and Mr. Hayford's of the distribution of density to cause isostasy are more in accordance with geological phenomena than my theory of mountain roots supported in a dense liquid substratum. But in Colonel Burrard's reply[1] to my paper in the Magazine for June there is a fundamental but specious error. I wrote: "Is it not possible that the earth's rotation may impart to it a 'gyroscopic' *quasi* rigidity, which may enable it to withstand the deforming influence of external forces [the attraction of the moon and sun], although at the same time forces internal to the earth will

[1] This Magazine, September, 1913.

be unaffected by it." To this Colonel Burrard replies: "Mr. Fisher has argued that the rotation of the earth will give to the liquid interior an effective rigidity; but this rotation has conferred no rigidity upon our oceans, and even if it did render the liquid interior rigid, it would only do so in low latitudes where the rotation velocity is high. I understand, moreover, that the earth's interior was assumed by Mr. Fisher to be liquid, in order to explain the floatation of the crust. If the liquid is now proved to be rigid, the crust cannot be floating upon it." Colonel Burrard forgets that the ocean and the earth's crust, being part of the rotating mass, the forces acting on them are *internal*, and will not be affected by the gyroscopic rigidity, which exists only with reference to *external* forces. It is true that this rigidity will be greatest in the equatorial regions, but it is in those regions that the tidal forces chiefly act, and require to be, and are, met by this theory.

Colonel Burrard asks, "How can computers test a theory when the limits and size of the roots are not exactly defined?" My answer is, how can I define the limits and size of the roots, believing as I do that mountains are partly supported by the rigidity of the crust? Is it likely that where the crust has been thickened by compression, part being sheared upwards and part downwards into the substratum, the compressed area should have become detached from the adjoining crust, so as not to depress it to some distance away, along with it? And if that depression became covered by detritus it also would appear to have a root. In fact, the simplicity, very naturally desired by geodesists, is not to be expected. But the lack of it does not condemn the theory of mountains having roots projecting into a dense liquid substratum, and that this arrangement tends to produce isostasy.

In a note at p. 387 Colonel Burrard controverts my argument against solidity, drawn from the observed changes of gravity since 1873 at Dehra Dun; and says that the change is apparent only and due to the vibration of the pendulum's support. But in his paper at the Royal Society, 1906, he wrote: "The only faults which have been found with their [the observers' of 1865–73] work, are such as would tend to produce constant error." And he gives the following list:—

"The force of gravity as observed by—

	Basevi and Heaviside, 1865–73. cm.	Lenox Conyngham, 1904. cm.	Difference. cm.
Dehra Dun. . . .	978·962	979·065	+0·103
Madras	978·237	978·281	+0·044
Bombay	978·605	978·632	+0·027
Mupooner	978·751	978·795	+0·044"

Now it will be seen that the difference at the four stations mentioned is *not* constant, but is more than twice as great at Dehra Dun than at the other three. This would be in accordance with the changes still said to be going on there, to which I referred as reported in *Nature*.

III.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the June Number, p. 250.*)

(PLATE XIV.)

Cribrilina Gregoryi, mihi.[1] (Pl. XIV, Figs. 1–3.)

THE original figure of this species was rather diagrammatic and requires supplementing. Figs. 1 and 2 are from the type-specimen, Fig. 2 being given to illustrate the rectangular aperture which the species has a tendency to develop, though quite irregularly; this rectangular outline appears to be due to the amalgamation of the two prominent tubercles into a straight-edged cap which hides the arched part of the upper lip and may be oœcial in function. The typical form of the species is definitely established in the *Marsupites* zone (= *Marsupites* band of many authors), though it only becomes abundant in the succeeding zone.

Fig. 3 illustrates a form which occurs sparingly in the upper part of the zone of *M. cor-anguinum*, free-growing specimens of which have the strongly punctate basal lamina of this species, and which I regard as probably a developmental stage of it; distinct traces are shown of an aperture with six tubercles on the upper lip, four of which fail to persist.

Cribrilina suffulta, sp. nov. (Pl. XIV, Figs. 4, 5.)

Zoarium unilaminate, adherent.

Zoœcia practically zoœcia of a typical pyriform *Membranipora* such as *M. Triminghamensis*, *mihi*,[1] with a highly arched Cribrilinid front wall added; the front wall is in two sections, divided longitudinally by a stout rib; the outer section rises at a steep angle from the side walls to support this rib, and is pierced by a series of narrow radiating slits; the inner section is enclosed by a row of pores along the inner side of the rib, corresponding very regularly with the slits outside; it is markedly depressed and has a few pores scattered irregularly over it; the aperture is roughly semicircular, its lower lip being strongly arched, as it is formed by the thickened edge of the arched front wall, while its upper lip is flat and bears very faint tubercles, apparently five in number normally.

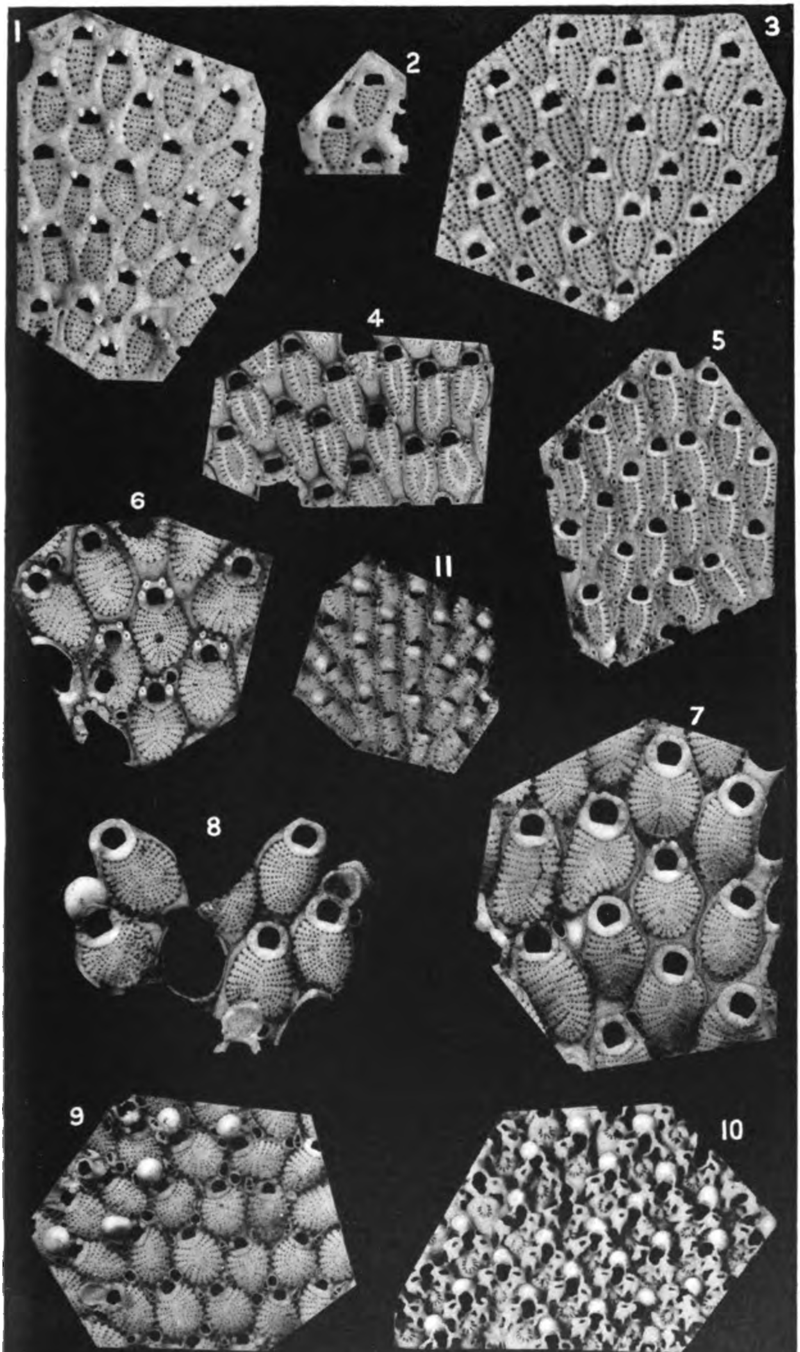
Oœcia probably represented by wide, shallow, hood-like swellings of the upper lip, having a straight free edge, which make the apparent outline of the aperture quite sharply oblong.

Avicularia corresponding very closely in shape, size, and disposition with those of *C. Gregoryi*.

This species occurs in the *cor-anguinum* zone and *Uintacrinus* band sparingly, and I have a specimen from the zone of *O. pilula* (sub-zone of abundant *O. pilula*). It is obviously intermediate between *Cribrilina* and *Membraniporella*, and, in accordance with my previous practice in such cases, I have attributed it to the former.

The normal aspect of the species (Fig. 4) presents little obvious relationship to *C. Gregoryi*, but in Fig. 5 I have illustrated a specimen which I think must be regarded as a coarse form of *C. suffulta*, and which

[1] Geol. Mag., 1906, pp. 289–300.



R. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.

shows a very close approach to the early coarse form of *C. Gregoryi* illustrated by Fig. 3, and makes it important to inquire what sure distinctions can be drawn between these species. The most prominent feature of *C. suffulta* is the arched front wall with depressed central area—it does not show up well under the microscope but is very striking under a pocket lens—but this feature is occasionally very closely imitated, owing no doubt to local conditions, in an otherwise typical zoarium of *C. Gregoryi*. But the slits in the front wall, which in *C. suffulta* replace pores in *C. Gregoryi*, and the stout paired tubercles at the upper end of the aperture of *C. Gregoryi*, seem to be absolutely reliable distinctions.

CRIBRILINA CACUS,[1] sp. nov. (Pl. XIV, Figs. 6–8.)

Zoarium unilaminate, always encrusting.

Zoœcia subpyriform and very large for this genus, such measurements as 1·2 mm. for length and ·9 mm. for breadth being quite usual; side walls quite distinct; front walls lying on the side walls, flatly convex, pierced by from twenty to twenty-six rows of pores more or less opposed in pairs, the pores tending to increase markedly in size at the outer ends of the rows; aperture definitely but not strongly horseshoe-shaped and bearing on its rim four or five more or less perforated tubercles, the lower pair much stouter and less deeply perforated than the upper ones, while when three upper ones are present the middle one of them tends to be distinctly more slender than the others.

Oœcia quite scarce and very brittle, the one figured (Fig. 8) being the only perfect one I have yet seen: it was very large and globular with a tendency to a bottle neck, and two stay-like rods running obliquely upwards to it from the sides of the aperture; unfortunately it was destroyed by an accident after it had been photographed.

Avicularia perhaps represented by shallow, slightly ear-shaped rings sparingly tucked away among the zoœcia, resembling those more freely found in *Cribrilina Dibleyi, mihi.*[2]

This species, which occurs from time to time at Trimingham, might almost be regarded as a double scale variety of *C. Dibleyi*, a figure of which is given for comparison. At the same time, this giant form occurs often enough to indicate the existence of a definite race; and as there are no intermediate forms, and the difference in size is so considerable, I have thought it justifiable to constitute it a separate species. Support may be found for this view in the differing shapes of the respective apertures and the total absence from *C. Cacus* of anything to correspond with the graceful and abundant avicularia of *C. Dibleyi*. *Cribrilina Guascoi*, Ubaghs, sp. (*Escharipora Guascoi*, Ubaghs, *Verh. d. Nat. Ver. Preussen Rheinl.*, Jahrg. xxii, p. 51, taf. ii, fig. 3), seems a close parallel in size and general type.

MEMBRANIPORELLA SHERBORNI, mihi sp. (Pl. XIV, Fig. 10.)

Syn. *Cribrilina Sherborni, mihi.*[2]

Further investigation has shown that the radiating ribs of the front wall are not united to one another in any way, and the species must

[1] Cacus, a giant in Latin mythology.

[2] GEOL. MAG., 1906, pp. 289–300.

therefore be classed as a *Membraniporella.* A photographic figure of a suitable specimen is given to supplement the original diagrams.

MEMBRANIPORELLA JUKES-BROWNEI, mihi sp. (Pl. XIV, Fig. 11.)

Syn. *Cribrilina Jukes-Brownei, mihi.*[1]

Here, too, the structure of the front wall appears to involve the transference of the species to *Membraniporella*, and the original diagrams are supplemented by a photographic figure. Restudy of this species has left me with a strong impression that it is closely related to, if not directly descended from, *Membraniporella fallax, mihi*, notwithstanding the considerable difference there is between them at first sight.

EXPLANATION OF PLATE XIV.

(All figures × 12 diams.)

FIGS. 1, 2.	*Cribrilina Gregoryi.* Different parts of type-specimen. Zone (restricted) of *A. quadratus.* Upham, Hants.	
FIG. 3.	*C. Gregoryi.* Zone of *M. cor-anguinum.* Basingstoke.	
FIGS. 4, 5.	*C. suffulta*, sp. nov. Zone of *M. cor-anguinum.* Gravesend.	
FIGS. 6–8.	*C. Cacus*, sp. nov. Trimingham.	
FIG. 9.	*C. Dibleyi.* ,,	
,, 10.	*Membraniporella Sherborni.* Trimingham.	
,, 11.	*M. Jukes-Brownei.* ,,	

IV.—CLASSIFICATION OF YOUNGER STRATIFIED FORMATIONS OF NEW ZEALAND.

By Professor JAMES PARK, F.G.S., Otago University, Dunedin, New Zealand.

I DO not think there is likely to be much gain from a prolonged discussion of this matter, and for the present I shall content myself with a brief recapitulation of the position so far as it affects the views of Dr. P. Marshall on the one hand and of Captain Hutton and myself on the other.

1. At various places in the maritime regions of New Zealand, throughout a length of 1,000 miles, there exist a Cretaceous succession and a Lower Tertiary succession of sedimentary strata. Both successions contain several fossiliferous horizons, and in many places fossils are numerous and well preserved. By the aid of these fossiliferous horizons the Geological Survey has been able to divide these strata into eight easily recognizable series.

The Cretaceous strata always rest on Jurassic or older rocks. The Lower Tertiary beds rest sometimes on the Cretaceous strata, but most often on formations older than Cretaceous.

In the central regions of New Zealand, as at Waipara, Weka Pass, Clarence Valley, Akiteo, and Poverty Bay, the physical unconformity between the Cretaceous and Lower Tertiary is absurdly slight, so slight that it cannot be distinguished in many single sections. At each end of this central region, as at Shag Point and Kaitangata in Otago, and Wade and Kaipara in North Auckland, the conformity is quite clear and unmistakable.

Captain Hutton's first acquaintance with the Lower Tertiary and Cretaceous strata was made in the East Cape and North Canterbury

[1] GEOL. MAG., 1906, pp. 289–300.

districts, and their apparent stratigraphical conformity led him in the early seventies to establish his Cretaceo-Tertiary System. Even at that time he clearly recognized the purely secondary character of the fauna of the Cretaceous element of the succession, and the equally distinctive Tertiary facies of that prevailing in the uppermost strata. There was no commingling of Cretaceous and Tertiary types, and, realizing that a Cretaceo-Tertiary System could not be maintained on purely stratigraphical grounds, he unhesitatingly abandoned his own creation.

The Geological Survey, which adopted Hutton's Cretaceo-Tertiary System from the first, continued to support it for some years; but for the past quarter of a century the Survey has offered no defence of it.

Dr. Marshall viewed the Weka Pass sections two or three years ago, and in his maiden flight in the domain of classification 'lumped' all the Cretaceous and Tertiary strata into one system, which he designated his "Oamaru System (Cainozoic—mostly early)". A Tertiary system containing *Baculites*, *Ammonites*, *Inoceramus*, *Belemnites*, as well as *Plesiosaurus*, *Mosasaurus*, and other secondary reptiles, is a geological curiosity of a very novel kind. This is a grave blunder which fortunately carries its own correction. It appears to have arisen from an exaggerated notion of the value of physical conformity in the role of classification. For the past century the main and minor subdivisions of the geological record have been based on palæontological grounds alone. No dependence can be placed on physical conformities and unconformities, which are simply an expression of local geographical conditions.

2. So much for the general discussion. Turning to some details in Dr. Marshall's letter in your June number, he states that "where the Amuri Limestone has been found there is a thickness of 500 to 2,000 feet of strata that have up to the present time yielded no fossils". This is an error, and apparently made in ignorance of the fact that the Geological Survey has found Cretaceous fossils right up to the base of the Amuri Limestone in the Clarence Valley and at Amuri Bluff. Moreover, Dr. Marshall omits to mention the fact that no Tertiary fossils have ever been found below the Amuri Limestone in any part of New Zealand.

3. Dr. Marshall states that the stratigraphical break between the Cretaceous and Lower Tertiary strata as exposed at Orewa and Kaipara is due to slipped ground. The too frequent appeal to the hypothetical slip lacks conviction. These sections were first described and figured by me over twenty-five years ago, and on account of their important bearing on the relationship of the Tertiary and Cretaceous systems were subsequently critically examined by Sir James Hector and Alex. McKay. These experienced geologists made no attempt to evade the obvious evidence of unconformity.

4. Dr. Marshall represents me as saying that I had not previously to 1912 critically examined the surface of the Amuri Limestone for Hutton's unconformity. My paper on the "Lower Tertiary Rocks of New Zealand",[1] with my description and sections of the Weka Pass district, should have made it clear enough that I did not refer to the

[1] Trans. N.Z. Institute, vol. xxxvii, 1904.

surface of the Amuri Limestone as exposed at Wekà Pass, but to the exposures at the Upper Waipara, where fossils were recently found in the Weka Pass Stone by Dr. Thomson and concerning which I was writing at the time.[1]

The evidence of an unconformity between the Weka Pass Stone and Amuri Limestone at Weka Pass is very meagre, but at the Upper Waipara the corroded, shattered, and brecciated upper surface of the Amuri Limestone certainly favours Hutton's view of unconformity; and comparing the evidence with that I have seen at the junction of the Eocene and Cretaceous in the section across the Isle of Wight, in the Hampshire Basin, in different parts of the Gallic Basin, in North-West Germany, and in Northern Africa, I have no doubt that European geologists would support Hutton's contention. But the question after all is not dependent on physical conformity or unconformity, but on the broader platform of palæontology. So long as a Cretaceous fauna is held to typify a Cretaceous age and a Tertiary fauna a Tertiary age, so long must Hutton's Waipara and Oamaru Systems stand as typical of New Zealand's Cretaceous and Lower Tertiary formations respectively.

V.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[2]

More than twenty years ago, whilst engaged in the study of the Lower Carboniferous rocks of Westmorland, I noticed the occurrence of certain small concretionary nodules of very compact texture in the dolomites near the base of the succession in the neighbourhood of Shap.

Shortly afterwards, when examining the Bernician rocks of Northumberland, I again met with similar compact nodular structures. It was obvious, however, even at that time, that the Northumberland specimens occurred here at a much higher horizon than those which I had observed in Westmorland.

More recently, whilst studying the lithological characters of the Lower Carboniferous rocks of the North of England and the Border country, I have been still further impressed by the abundance of these nodular structures at several horizons, and the large tracts of country over which they extend. An examination of these nodules in thin sections showed their obvious organic character, and I was at first inclined to refer them to the Stromatoporoids. Dr. G. J. Hinde, who was kind enough to examine my specimens from the Shap district, reported, however, that they were probably not Stromatoporoids, but Calcareous Algæ,[3] and referred me to the descriptions of *Solenopora* published by the late Professor Nicholson and Dr. Brown.

[1] "The Supposed Cretaceo-Tertiary Succession of New Zealand," Geol. Mag., November, 1912, pp. 496–7.

[2] Being the substance of his address to the Geological Section of the British Association for the Advancement of Science, Birmingham, 1913 (President of Section C).

[3] See Geol. Mag., 1913, pp. 289–92, Pl. X: Dr. G. J. Hinde on *Solenopora*.

Since then I have examined a large number of nodules collected from different horizons in the Lower Carboniferous rocks of Britain and Belgium, and the examination has convinced me that the remains of Calcareous Algæ play a very much more important part in the formation of these rocks than has hitherto been generally realized.

The majority of geologists in this country have been slow to recognize the importance of these interesting organisms, and, with the notable exception of Sir Archibald Geikie's textbook, we find but scant allusion in English geological works of reference to the important part played by Calcareous Algæ in the formation of limestone deposits.[1]

From the more strictly botanical standpoint, however, we are indebted to Professor Seward for an admirable account of the forms recognized as belonging to this group up to the date of the publication of his textbook on Fossil Plants in 1898; while in an article in *Science Progress* in 1894 he has also dealt with their importance from a geological point of view.

Since these publications, not only have several new and important genera been discovered in this country and abroad, but the forms previously known have also been found to have a very much wider geological and geographical range than was formerly suspected. For these reasons I venture to hope that a summary of our knowledge of the part they play as rock-builders, more especially in British deposits, will serve to stimulate an interest among geological workers in this country in these somewhat neglected organisms.

Previous to 1894, in which year Dr. Brown first referred *Solenopora* to the Nullipores, with the exception of the Jurassic and Tertiary Characeæ, we meet with little, if any, reference to the occurrence of fossil Calcareous Algæ in British deposits.

Indeed, in this country the subject has attracted but few workers, and they can almost be counted on the fingers of one hand. When we have mentioned the late Professor H. A. Nicholson and Mr. Etheridge, jun., Mr. E. Wethered, Dr. Brown, Dr. Hinde, and Professor Seward, we have practically exhausted the list of those who have contributed to our knowledge of the subject. To these we may add the name of Mrs. Robert Gray, whose magnificent collection of fossils from the Ordovician rocks of the Girvan district has always been freely placed at the disposal of geological workers, and has furnished numerous examples of these organisms to Professor Nicholson and the officers of the Geological Survey.

It was Nicholson and Wethered who first recognized the important part played in the formation of limestones by certain organisms, which, though referred at the time to the animal kingdom, are now generally considered to represent the remains of Calcareous Algæ.

The presence of these organisms in a fossil state, especially in the older geological formations, has only been recognized in comparatively recent years; though it was suggested as long ago as 1844 by Forchhammer[2] that fucoids, by abstracting lime from sea water, probably contributed to the formation of Palæozoic deposits. When

[1] Geikie, *Textbook of Geology*, 4th ed., vol. i, pp. 605, 611, 1903.
[2] British Association, 1844, p. 155.

we remember that it was not until the researches of Philippi were published in 1837 that certain calcareous deposits were discovered to be directly due to the growth of living forms of lime-secreting algæ, it is not surprising that only in comparatively recent years has the importance of the fossil forms as rock-builders in past geological formations been recognized.

The original genera established by Philippi—namely, *Lithothamnion* and *Lithophyllum*—are known now to have a wide distribution in the present seas, and it is therefore natural that it was members of these groups which were the first to be recognized in a fossil state in Tertiary and, subsequently, in Upper Cretaceous rocks.

Thus in 1858 Professor Unger, of Vienna, showed the important part played by *Lithothamnion* in the constitution of the Leithakalk of the Vienna Basin, while seven years later Rosanoff contributed further to our knowledge of Tertiary forms. In 1871 Gümbel published his monograph on the "so-called Nullipores found in limestone rocks", with special reference to the *Lithothamnion* deposits of the Danian or Maestricht beds. Since then *Lithothamnion* has also been reported from Jurassic rocks, and even from beds of Triassic age, though in the latter case, at all events, the reference to this genus appears to require confirmation. In this country the recognition of fossil Calcareous Algæ dates from a considerably later period. It will be best first to review the chief genera which appear to be referable to the Calcareous Algæ, and afterwards to show the part they play as rock-builders in the different geological formations.

Two important genera are usually recognized at the present day as occurring in the British Palæozoic and Mesozoic rocks—namely, *Solenopora* and *Girvanella*—and to these I propose to add Wethered's genus, *Mitcheldeania*, together with certain new forms from the Carboniferous rocks of the North of England, which appear also to be referable to this group.

Solenopora.

This genus was first created by Dybowski in 1877 for the reception of an obscure organism, from the Ordovician rocks of Esthonia, which he described under the name *Solenopora spongioides* and regarded as referable to the Monticuliporoids.

Nicholson and Etheridge in 1885 (Geol. Mag., p. 529) showed that the form described by Billings in 1861 as *Stromatopora compacta*, from the Black River limestones of North America, was in reality Dybowski's genus *Solenopora*, and in all probability was specifically identical with the form from Esthonia. Moreover, they considered that the organism they themselves had described under the name of *Tetradium Peachii* in 1877, from the Ordovician rocks of Girvan, was also referable to Billing's species, though perhaps a varietal form. Thus *Solenopora compacta* was shown to have a very wide distribution in Ordovician times.

Nicholson in 1888 defined the genus as including "Calcareous organisms which present themselves in masses of varying form and irregular shape, composed wholly of radiating capillary tubes arranged in concentric strata. The tubes are in direct contact, and no cœnenchyma or interstitial tissue is present. The tubes are thin-walled, irregular in form, often with undulated or wrinkled walls, without mural pores, and furnished with more or fewer transverse partitions or tabulæ".[1]

At that time Nicholson still considered *Solenopora* as representing a curious extinct hydrozoon, though already, in 1885, Nicholson and Etheridge had discussed its possible relationship to the Calcareous Algæ. They did not, however, consider that there was sufficient evidence for concluding that the true structure of *Solenopora* was cellular, but added: "If evidence can be obtained proving decisively the existence of a cellular structure in *Solenopora*, then the reference of the genus to Calcareous Algæ would follow as a matter of course."[2]

In 1894 Dr. A. Brown[3] investigated more fully the material which had been placed in his hands by Professor Nicholson, and gave an account of all the forms referable to *Solenopora* known at that date.

To those already recorded he added descriptions of four new species from the Ordovician rocks—namely, *S. lithothamnioides*, *S. fusiformis*, *S. nigra*, and *S. dendriformis*, the two latter being from the Ordovician rocks of Esthonia.

In the same paper also he published for the first time a description of a new species of *Solenopora* from the Jurassic rocks of Britain, to which Nicholson, in manuscript, had already assigned the name of *S. jurassica*, though, as will be pointed out later, it is probable that two distinct forms were included by Brown under this name.

This record of *Solenopora* from the Lower Oolites of Britain extended the known range of this genus, for the first time, well into the Jurassic period. In this paper Brown first brought forward good evidence for removing *Solenopora* from the animal kingdom, and placing it among the Coralline Algæ, and Professor Seward, in vol. i of his work on *Fossil Plants*, considers that there are good reasons for accepting this conclusion.

At the time of the publication of Dr. Brown's paper, and for some years afterwards, the only formations in which *Solenopora* was known to occur were the Upper Ordovician and the Lower Oolites. The diversity of forms, however, met with in the Ordovician rocks, and their widespread distribution, pointed to the probability of the existence of an ancestral form in the older rocks, while it also appeared incredible that no specimens of intervening forms should have been preserved in the rocks representing the great time-gap between the Ordovician and Jurassic formations.

In this connexion Professor Seward remarks[4]: "It is reasonable to prophesy that further researches into the structure of ancient limestones will considerably extend our knowledge of the geological and botanical history of the Corallinaceæ." This prophecy has been amply fulfilled, especially as regards this particular genus, and recent discoveries go far towards filling the previously existing gaps in our knowledge of the vertical distribution of this interesting genus.

[1] GEOL. MAG., Dec. III, Vol. V, p. 19, 1888.
[2] GEOL. MAG., Dec. III, Vol. II, p. 534, 1885.
[3] GEOL. MAG., Dec. IV, Vol. I, pp. 145 and 195, 1894.
[4] *Fossil Plants*, vol. i, p. 190, 1898.

Thus the recent detection in the lowest Cambrian rocks of the Antarctic Continent of a form which appears to be referable to this genus enables us to trace the ancestry of *Solenopora* back almost to the earliest rocks in which fossils have yet been discovered, while the gap in the succession which previously existed between the Ordovician and Jurassic forms was decreased by the description in 1908 by Professor Rothpletz of a new species *Solenopora gotlandica*, from the Silurian rocks of Faröe Islands in Gotland.[1] A large number of deposits, however, still remained, between the Gotlandian and Lower Jurassic beds, from which no example of *Solenopora* had so far been recorded.

The identification, therefore, a few years ago, by Dr. G. J. Hinde, of examples of this genus from among the nodules I had collected from the Shap dolomites, is of considerable interest, as the presence of *Solenopora* in the Lower Carboniferous rocks of this country materially decreases the gap in our knowledge of the succession of forms belonging to this genus which had previously existed.

Girvanella.

This organism, which is now known to be widely distributed in the Palæozoic and Mesozoic rocks of this country, was originally described in 1878 by Nicholson and Etheridge, jun., from the Ordovician rocks of the Girvan district. The genus was established to include certain small nodular structures composed of a felted mass of interlacing tubes, having a width of 10 and 18 μ, the cells being typically simple, imperforate tubes without visible internal partitions. The geno-type, *G. problematica*, was, however, at that time referred to the Rhizopods and regarded as related to the arenaceous foraminifera.[2] In 1888 Nicholson, in redescribing this genus in the GEOLOGICAL MAGAZINE, compares *Girvanella* with the recent form *Syringammina fragillissima* of Brady.

More recently Mr. Wethered has shown that an intimate association frequently exists between *Girvanella* tubes and oolitic structure, and he has described several new species of *Girvanella* from the Palæozoic rocks and also from certain Jurassic limestones.

The reference of *Girvanella* to the Calcareous Algæ, though not yet supported by incontestable evidence, has been advocated by several writers in recent years. Even as long ago as 1887, Bornemann, in describing examples of *Siphonema* (*Girvanella*, Nich.) which he had discovered in the Cambrian rocks of the Island of Sardinia, suggested that this organism might belong to the Calcareous Algæ.

In 1891 Rothpletz[3] noticed that some of the specimens of *Girvanella* which he had examined were characterized by dichotomous branching of the tubes; on this account he removed the genus from the Rhizopods to the Calcareous Algæ, placing it provisionally among the Codiaceæ. Three years later Dr. A. Brown, in summing up the evidence in favour of the inclusion of *Solenopora* among the Nullipores, expressed

[1] *Kungl. Svenska, Vets. akad. Handl.*, Bd. 43, No. 5, pl. iv, pp. 1–5 and 14, 1908.

[2] *Silurian Fossils in the Girvan District*, 1878, p. 23.

[3] Zeitschr. d. D. Geol. Gesell., 1891.

the opinion that *Girvanella* might ultimately come to be regarded as referable to the Siphoneæ Verticillatæ.

In 1898, however, this genus was still only doubtfully placed with the Calcareous Algæ, for Seward, in his work on *Fossil Plants*,[1] remarks: "The nature of *Girvanella*, and still more its exact position in the organic world, is quite uncertain. . . . We must be content for the present to leave its precise nature still *sub judice* and, while regarding it as probably an alga, we may venture to consider it more fittingly discussed among the Schizophyta than elsewhere."

In 1908, however, Rothpletz, in discussing the relationship of *Spherocodium* and *Girvanella*, reaffirms his opinion that the latter must be referred to the Codiaceæ.[2]

Mitcheldeania.

This genus was first described by Mr. Edward Wethered from the Lower Carboniferous beds of the Forest of Dean[3] under the name of *Mitcheldeania Nicholsoni*; it was referred by him to the Hydractinidæ, and considered to be allied to the Stromatoporoids. The figure accompanying this paper unfortunately fails to show any of the characters of the organism, but a better figure of the same species was subsequently published in the Proceedings of the Cotteswold Naturalists' Field Club.[4]

In 1888 Professor H. A. Nicholson published in the Geological Magazine[5] figures and descriptions of a new species of this genus (*M. gregaria*), and redefined the genus as having "the form of small, rounded or oval calcareous masses made up of capillary tubes of an oval or circular shape, which radiate from a central point or points, and are intermixed with an interstitial tissue of very much more minute branching tubuli". He compares the larger tubes to zooidal tubes, and states that they "communicate with one another by means of large, irregularly-placed foramina resembling 'the mural pores' of the Favositidæ, and they occasionally exhibit a few irregular transverse partitions or tubulæ".

With regard to the systematic position of this genus Nicholson remarks: "In spite of the extreme minuteness of its tissues, the genus *Mitcheldeania* may, I think, be referred with tolerable certainty to the Cœlenterata . . . its closest affinities seem to be with the Hydrocorallines . . . on the other hand all the known Hydrocorallines possess zooidal tubes which are enormously larger than those of *Mitcheldeania*; and there are other morphological features in the latter genus which would preclude its being actually placed, with our present knowledge, in the group of the *Hydrocorallinæ*."

Since this description by Professor Nicholson no further account of this organism, so far as I am aware, has been published, and its reference to the *Hydrozoa* rests on Professor Nicholson's description.

During the past few years I have collected a large amount of material from both of the type localities from which Mr. Wethered

[1] Op. cit., vol. i, p. 125.
[2] Rothpletz, Kungl. Sven. Vets. Akad. Hardl., Bd. 43, No. 5, loc. cit., 1908.
[3] Geol. Mag., Dec. III, Vol. III, p. 535, 1886.
[4] Vol. ix, p. 77, pl. v, 1886. [5] Op. cit., p. 16.

and Professor Nicholson obtained their specimens, and an examination of this material has impressed me strongly with the resemblance of *Mitcheldeania* to forms such as *Solenopora* and *Girvanella*, now usually classed among the Calcareous Algæ. In the rocks in which it occurs *Mitcheldeania* appears as rounded and lobulate nodules, breaking with porcellanous fracture and showing concentric structure on weathered surfaces, very similar to nodules of *Solenopora*; while under the microscope the branching character of the tubules and their comparatively minute size appear to separate them from the Monticuliporoids. Professor Nicholson appears to rely on the presence of pores, which he thought he observed in the walls of both the larger and finer tubes, for the inclusion of this genus with the Hydrocorallines, though he appeared to be doubtful about their occurrence in the interstitial tubuli. An examination of a large number of slides has failed to convince me of the presence of pores, even in the larger 'zooidal tubes'. The large 'oval or circular' apertures noticed by Nicholson appear to be either elbows in the undulating tubes cut across where these bend away from the plane of the section, or places where a branch is given off from a tube at an angle to the plane of the section. If this view be accepted, there appears to be no sufficient reason why *Mitcheldeania* should not be ranged with *Solenopora* and other similar forms, and included among the Calcareous Algæ—a position which its mode of occurrence and general structure has led me, for some time, to assign to this organism.

In addition to the three chief forms described above from British rocks, a study of numerous thin sections from the Lower Carboniferous rocks of the north-west of England has revealed the presence of several distinct organisms, which will, I think, eventually be found to be referable to the Calcareous Algæ.

This meagre list appears to exhaust the genera known at the present time from the Lower Carboniferous rocks of Britain, while the only additional genus so far recorded from the Mesozoic and Tertiary rocks of this country (if we accept Rothpletz's sub-genus *Solenoporella*) is *Chara* from the Wealden beds of Sussex, the uppermost Jurassic of the Isle of Wight and Swanage, and the Oligocene of the Isle of Wight.

Outside this country the literature on fossil Calcareous Algæ is much more extensive. The interest originally aroused on the Continent by the writings of Philippi, of Unger of Vienna, Cohn, Rosanoff, Gümbel, Saporta, and Munier-Chalmas, has been further maintained in our own time by Bornemann, Steinmann, Früh, Solms-Laubach,[1] Rothpletz, Walther, Kiaer, and others; while the more favourable conditions which obtained for the growth of these organisms, especially during Silurian, Triassic, and Tertiary times, has afforded a much wider field for their observation.

Thus, in addition to the forms recorded from this country, an important part has been played by members of the family of the Dasycladaceæ, together with such genera as *Sphærocodium*, *Lithothamnion*, and *Lithophyllum*.

(*To be continued in our next Number.*)

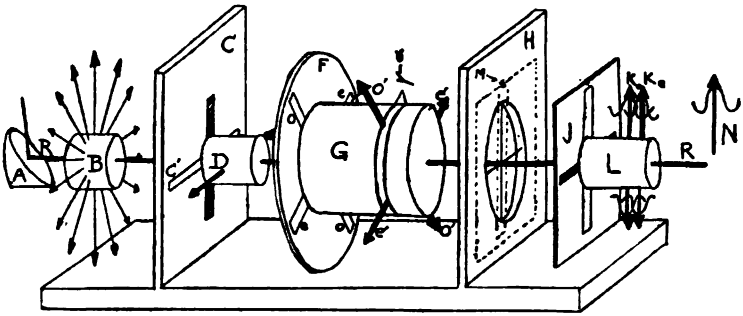
[1] *Fossil Botany* (Oxford), 1891.

VI.—A Model for a Polarizing Microscope.

By W. N. Benson, B.A., B.Sc., Emmanuel College, Cambridge.

PROBABLY most teachers of petrology have experienced difficulty in making clear to some elementary students the manner in which light is transmitted through a polarizing microscope, and the explanation of birefringence and pleochroism. In such circumstances I have found very helpful the analogies illustrated by an easily constructed model. Doubtless such an instrument has been used before, but, as the textbooks make no mention of it, a description may be of use here.

It consists of a number of portions strung on a stout wire or knitting-needle (*RR* in figure), which represents the path of the pencil of rays along the axis of the microscope. The rays falling on the mirror *A* (a cork) are reflected along *RR*, and the pencil is made up of rays vibrating across *RR* in every azimuth (as shown by *B*).



RR, path of ray through microscope axis (lenses not represented); the arrows indicate the planes of vibration; *A*, sub-stage mirror; *C*, polarizer; *D*, plane polarized light; *F*, crystal plate; *H*, cross-wires; *J*, analyser; *Ko Ke*, interference of vibrations brought into the same plane by the analyser (birefringence).

On reaching *C*, the polarizer, each of these rays is resolved into two directions, but is transmitted along one only of these directions (through the slot *C′*). Thus all the light leaving the polarizer vibrates in one plane, as shown by the arrow through the cork *D*, which is rigidly connected with *C*. *F*, representing the crystal plate, rotates freely about *RR*. The light from the polarizer is resolved into two directions perpendicular to each other, and is transmitted through the crystal as through the slots *o* and *e*. In this passage, however, one ray is retarded more than the other, so that the nature of the light as it leaves the crystal plate is illustrated by the two arrows *o′* and *e′* driven through the cork *G*, which is rigidly connected to *F*. As the crystal is rotated the intensity of the *o* and *e* rays vary, and this may be indicated by pushing the corresponding arrows in or out of the cork *G*. The board *H* shows the position of the cross-wires in the microscope, and serves to hold *RR* in place. The analyser *J*, and vibration arrows *Ko* and *Ke* are attached to the cork *L*, which slides on or off *RR*. When properly in position for the 'crossed nicols' condition the analyser is held in place against *H* by the small stop *M*. The *o'* and *e'* rays from the crystal on entering the analyser are resolved into two components, and of these only one is transmitted. The light leaving the analyser is therefore made up of the resolved portions of *o'* and *e'*, and is indicated by the arrows *Ko* and *Ke*, both lying in the same plane, but one behind the other.

The way for the more rigid explanation of the birefringence colours is often made easy by some such phrase as the following: "The two resolved portions of the polarized ray enter the crystal plate perfectly 'in step', but as one is retarded more than the other while passing through the crystal, it falls behind, and when brought by the analyser into the same plane the two rays are found to be no longer 'in step', and consequently interfere with each other." The interference can be illustrated by soldering to each arrow a portion of a sine curve wire (as at *N*). By varying the distance between the arrows the quartz wedge and kindred phenomena can be well shown.

If a large cork be used for *L*, and the amplitudes of *Ko* and *Ke* be varied as with *o'* and *e'*, one can illustrate the impossibility of obtaining complete extinction with uncrossed nicols.

Pleochroism is exemplified by removing the analyser and clipping differently coloured glass plates (e.g. brown and green) over the *o* and *e* slots in the crystal plate *F*. The *o'* and *e'* arrows may be coloured accordingly, and the variation of the tint as the crystal is rotated is brought out well by varying the lengths of the *o'* and *e'* arrows as before, to give the two colour intensities in all positions. A little mechanical contrivance may be added to do this automatically, but would require nice workmanship.

The model may be used to illustrate several other points, but its application to these ends will occur to every teacher, and need not be mentioned here.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science, Eighty-third Annual Meeting, held at Birmingham, September 10-17, 1913. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Presidential Address by *Professor E. J. Garwood, M.A., V.P.G.S.* (see ante, p. 440).

Professor Charles Lapworth, F.R.S.—On the Geology of the Country round Birmingham.

Professor W. W. Watts, F.R.S.—Notes on the Igneous Rocks of the Birmingham District.

Mr. George Barrow.—The *Spirorbis* Limestones of North Warwickshire (see p. 463).

Mr. Henry Kay.—On the Stream-courses of the Black Country Plateau (see p. 457).

Professor W. J. Sollas, F.R.S.—On the Formation of Rostro-Carinate Flints.

Mr. E. A. Walford.—On the Structure of the Lias Ironstone of South Warwickshire and Oxfordshire (see p. 460).
Mr. T. C. Cantrill.—*Estheria* in the Bunter of South Staffordshire.
Mr. Leonard J. Wills & Mr. W. Campbell-Smith.—Notes on the Flora and Fauna of the Upper Keuper Sandstones of Warwickshire and Worcestershire (see p. 461).
Professor W. G. Fearnsides.—Nodules from the Basal Ordovician Conglomerate at Bryn Glas, Ffestiniog.
Dr. A. Vaughan.—The Division between the Lower and Upper Avonian.
Mr. F. G. Meachem.—On the Progress of the Coal-mining Industry of the South Midlands since the year 1886.
Dr. E. A. Newell Arber.—The Fossil Floras of the South Staffordshire Coal-field (see p. 462).
Mr. R. D. Vernon.—Correlation of Leicestershire Coal-field (p. 456).
Mr. George Barrow.—On Systems of Folding in the Palæozoic and Newer Rocks (see p. 463).
Dr. A. Irving.—The Harlow Boulder-clay and its place in the Glacial Sequence of Eastern England.
Mr. W. W. King & Mr. W. J. Lewis.—On the Discovery of Lower Carboniferous Grits at Lye, in South Staffordshire.
Mr. E. A. Walford.—The Basement Beds of the Great Oolite, the Crinoid Beds, and the place of *Rhynchonella concinna* in the Oolite Series (see p. 459).
Mr. A. R. Horwood.—The Value of a Knowledge of the Rock Soil Distribution of Plants in tracing Geological Boundaries.
Dr. A. H. Cox & Professor O. T. Jones.—The Geology of the District between Abereiddy Bay and Pencaer, Pembrokeshire (see p. 465).
Dr. Gertrude L. Elles.—The Relation of the Bala and Rhiwlas Limestones in the Bala District.
Mr. E. S. Cobbold.—Critical Sections of the Cambrian area called 'The Cwms' in the Caradoc–Comley region of Shropshire.
Dr. A. Irving.—Flint and its Genesis.
Dr. Marie C. Stopes.—Plant Petrifications in Chert and their Bearing on the Origin of Freshwater Cherts.
Dr. Vaughan Cornish.—On the Conditions which govern the Transport and Accumulation of Detritus by Wind and Water (see p. 455).
Dr. Gertrude L. Elles.—On Shelly and Graptolitic Faunas of the British Ordovician.
Miss Clara E. Sylvester.—A first Revision of the British Ordovician Brachiopoda.
Dr. L. Moysey.—Some further Notes on *Palæoxyris* and other allied Fossils, with special reference to some new features found in *Vetacapsula* (see p. 453).
Mr. Frank Raw.—On Sand-worn Rocks at Lilleshall.
Mr. V. C. Illing.—Recent Discoveries in the Stockingford Shales, near Nuneaton (see p. 452).
Mr. V. C. Illing.—Notes on certain Trilobites found in the Stockingford Shales (see p. 452).
Mr. W. D. Matthew.—Discoveries in the American Eocene.
Dr. H. Warth.—Classification of Igneous Rocks.

Mr. C. Carus-Wilson.—Copper in the Sandstones of Exmouth.
Dr. A. H. Cox & Professor O. T. Jones.—On various occurrences of Pillow-lavas in North and South Wales.
Dr. A. H. Cox.—Note on the Igneous Rocks of Ordovician Age.
Professor W. S. Boulton.—On a new form of Rock-cutting Machine.
Mr. C. H. Cunnington.—The Carboniferous Limestone at the Head of the Vale of Neath, South Wales.
Report of the Committee on Erratic Blocks of the British Isles.
Report of the Committee on the Investigation of the Igneous and Associated Rocks of Glensaul and Lough Nafooey Areas, Co. Galway.
Report of the Committee on preparing a List of Characteristic Fossils.
Report of the Committee on the further Exploration of the Upper Old Red Sandstone of Dura Den.
Report of the Committee on the Geology of Ramsey Island, Pembrokeshire.
Report of the Committee on the Old Red Sandstone Rocks of Kiltorcan, Ireland.
Report of the Committee on the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.
Report of the Committee to investigate the Microscopical and Chemical Composition of Charnwood Rocks.

Section A.—Mathematical and Physical Science.

Rev. A. L. Cortie, S.J.—Solar and Terrestrial Magnetic Disturbances.
Rev. H. V. Gill, S.J.—The Distribution of Earthquakes in Space and Time.
Mr. J. J. Shaw.—Exhibition of a Seismograph.

Section B.—Chemistry.

Professor W. M. Thornton.—The Influence of the Pressure of Gas on the Inflammability of Coal-dust in Air.
Dr. R. V. Wheeler.—The Composition of Coal.

Section D.—Zoology.

Presidential Address by *Dr. H. F. Gadow, F.R.S.*
Professor J. Versluys.—The Carapace of the *Chelonia*.
Professor W. K. Gregory.—Exhibition of a Fossil Skeleton of *Notharctus* sp., an American Eocene Lemur, with remarks on the Phylogeny of the Primates.
Dr. R. Broom—A Mammal-like Milk Dentition in a Cynodont Reptile.
Mr. C. Forster Cooper.—*Thaumastotherium osborni*, a new Genus of *Perissodactyles* presenting some unusual features.
Mr. D. M. S. Watson.—The early Evolution of the *Amphibia*.
Rev. Dr. A. Irving.—The Solutré type of Horse (*Equus robustus*) in Prehistoric Britain.
Professor R. J. Anderson.—On the Skull and Teeth of *Tarsiops*.
Professor R. J. Anderson.—Some Points concerning the Extremities, chiefly in the Mammalia.

Section E.—Geography.

Presidential Address by *Professor H. N. Dickson, D.Sc.*
Dr. C. A. Hill.—The Exploration of Gaping Ghyll, Yorkshire.
Professor W. W. Watts, F.R.S.—Notes on the Geography of Shropshire.

Professor J. W. Gregory, F.R.S.—On Australia.
Miss C. A. Simpson.—The Upper Basin of the Warwick Avon.
Mr. A. G. Ogilvie.—The Physical Geography of the Entrance to Inverness Firth.

SECTION G.—ENGINEERING.

Dr. Vaughan Cornish.—On Land Slides accompanied by Upheaval in the Culebra Cutting of the Panama Canal.
Mr. E. R. Matthews.—Harbour Projections and their Effect upon the Travel of Sand and Shingle.
Dr. J. S. Owens.—The Transport and Settlement of Sand in Water, and a method of exploring Sand Bars.

SECTION H.—ANTHROPOLOGY.

Dr. R. R. Marett.—Recent Archæological Discoveries in the Channel Islands.
Mr. W. Dale.—On present Speculations concerning the Age of certain forms of the so-called Neolithic Celt.
The Evolution of Man from the Ape—
(*a*) *Professor Carveth Reed.*—On the Differentiation of Man from the Anthropoids.
(*b*) *Dr. Harry Campbell.*—The Factors Determining the Evolution of Man from the Ape.
(*c*) *Dr. L. Robinson.*—The Relations of the Lower Jaw to Articulate Speech.
Dr. Capitan.—Recent Discoveries of Paintings in the Palæolithic Caves of the South of France.
Mr. T. C. Cantrill.—Stone Boiling in the British Isles.
Dr. T. J. Jehu & Mr. A. J. B. Wace.—Excavations in the Kinkell Cave, St. Andrews.
Mr. H. J. E. Peake.—The early Bronze Age in the Lower Rhone Valley.
Mr. O. G. S. Crawford.—Trade between England and France in the Neolithic and Bronze Ages.
Rev. F. Smith.—Palæolithic 'Guillotine' Trap-stones.
Rev. Dr. A. Irving.—Prehistoric Horse Remains in the Stort Valley.

SECTION K.—BOTANY.

Professor E. C. Jeffrey & Dr. D. H. Scott, F.R.S.—Devonian Plants showing Structure.
Mr. H. Hamshaw Thomas.—On a new type of Ginkgoalian Leaf.
Dr. E. de Fraine.—A new species of *Medullosa* from the Lower Coal-measures.
Professor F. W. Oliver, F.R.S.—On the Distribution of *Sueda fruticosa* and its role in the stabilizing of active Shingle.
Mr. P. H. Allen.—A Botanical Survey of Maritime Plant Formations of Hunstanton, Norfolk.
Mr. A. R. Horwood.—The influence of River Development on Plant Distribution.
Miss W. H. Wortham.—Some Features of the Sand-dunes in the south-west corner of Anglesey.

SECTION M.—AGRICULTURE.

Mr. J. Parry.—The Afforestation of Watersheds.

II.—*Abstracts of Papers read in Section C (Geology), Meeting of British Association, Birmingham, September 10–17, 1913.*

(1) Notes on certain Trilobites found in the Stockingford Shales. By V. C. Illing, B.A., F.G.S.

Among the fossils found at Hartshill Hayes, in the Abbey Shale subdivision of the Stockingford Shales, numerous forms occur, representing young stages in the development of certain Trilobite genera. Among these are the following:—

1. *Liostracus* sp.—The development is similar to that of *Liostracus* as described by G. F. Matthew.

2. *Holocephalina* sp.—The early stages of this genus possess a well-marked glabella, widening anteriorly. This becomes less convex in later stages, its anterior margin disappears, and finally the glabella is only represented by two short posterior grooves.

3. *Paradoxides Hicksii.*—The development is similar to that of *Paradoxides* as described by G. F. Matthew.

4. Certain new forms of *Agnostus.*—The anterior portion of the glabella becomes obliterated in the later stages, while the axis of the tail becomes relatively larger with increased development.

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(2) Recent Discoveries in the Stockingford Shales near Nuneaton. By V. C. Illing, B.A., F.G.S.

During recent mapping of the subdivisions of the Stockingford Shales between Nuneaton and Merevale, fossils have been found at various horizons which indicate that the Cambrian succession in this area is almost, if not quite, complete. Among these fossil-bearing horizons are the following:—

1. *Lower Purley Shales.*—Shales from a surface working 200 yards south of Worthington Farm, near Hartshill, contain fragments of *Olenellus.* The fossiliferous beds are 40 feet above the base of Purley Shales.

Mr. Pringle, of the Geological Survey, has found *Olenellus* in nodules at the base of the Purley Shales in Jee's Sett Quarry (Summary of Progress, 1913).

2. *Lower Oldbury Shales.*—(*a*) Excavations in Hartshill Hayes have proved that the basal 90 feet of the Oldbury Shales are of Menevian age. They contain the zones of *Paradoxides Davidis* and *P. Hicksii* in their upper and middle beds, while the lower beds contain *Agnostus atavus*, and correspond with Tullberg's *Ag. atavus* zone, and with part at least of the Lower Menevian of Sweden. The Trilobite fauna includes the genera *Paradoxides*, *Anopolenus*, *Conocoryphe*, *Holocephalina*, *Liostracus*, *Microdiscus*, and *Agnostus*, no less than fifteen species of the last genus having been found. At the top of the series there occurs a calcareous conglomerate, containing fragments of the underlying type of shale and indicating a probable unconformity.

(*b*) In a new cutting near Oldbury Reservoir *Olenus truncatus* and *Ag. pisiformis*, var. *obesus*, occur, proving that these beds are of Upper Maentwrog age.

Between the Maentwrog and Dolgelly horizons a series of curly bedded flagstones have been detected. These are very similar to the Ffestiniog Flags, and their position would seem to indicate that they are of Ffestiniog age. The beds are badly exposed and have yielded no fossils up to the present.

Thus the Oldbury Shales represent a large proportion of the Cambrian succession, and in view of this fact, and also of their extreme thickness (2,000 feet), I propose a further subdivision of this group, the classification of the whole succession being as follows :—

Merevale Shales		Lower Tremadoc.
Oldbury Shales	4. Monks Park Shales	Dolgelly.
	3. Moor Wood Flags and Shales	Ffestiniog.
	2. Outwoods Shales	Maentwrog.
	1. Abbey Shales	Menevian.
Purley Shales	Upper	Menevian (?).
	Mid	
	Lower	Taconian.
Hartshill Quartzite	Camp Hill Grit	
	Tuttle Hill Quartzite	
	Park Hill Quartzite	

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(3) Some further Notes on *Palæoxyris* and other allied Fossils, with special reference to some new features found in *Vetacapsula*. By L. Moysey, B.A., M.B., F.G.S.

SINCE the publication of a paper on *Palæoxyris* and other allied organisms in 1910 [1] so many fresh specimens have come to hand, and, as was only natural, several previously unrecorded examples have been described, notably some from the Lancashire Coal-measures by Mr. J. Wilfred Jackson,[2] that it seems desirable to record any new features that have been found in the later material, and also any new facts that may lead to the elucidation of the nature of these still very enigmatical organisms.

Taking in the first instance the genus *Palæoxyris*. The species *Palæoxyris helicteroides* (Morris) has been lately found in very large quantities in the Notts and Derbyshire Coal-field. In this area they seem to be restricted to an horizon extending from the roof of the Top Hard Coal downwards to above the Ell Coal; a careful search in the measures below, wherever these are exposed, has not resulted in the discovery of any trace of this fossil. They were, some years ago,[3] discovered in great numbers in the open working of the Barnsley thick coal at Worsborough, near Barnsley, where some 300 odd specimens were collected by Mr. W. Gelder from a space 6 or 7 yards in circumference, together with some specimens of *P. prendeli* (Lesq.) and *P. carbonaria* (Schimper).

A hurried search in other claypits at horizons above and below this coal during the Sheffield meeting of the British Association in 1910 produced enough specimens to make it probable that, if looked for, they may prove to be similarly quite common fossils in the great

[1] L. Moysey, Quart. Journ. Geol. Soc., vol. lxvi, pp. 329–45, pls. xxiv–vii, 1910.
[2] J. Wilfred Jackson, *Lancashire Naturalist*, January, 1911.
[3] R. Kidston, *Naturalist*, 1897.

coal-field of which the Notts and Derbyshire area is merely an extension.

In fact, it seems probable that the habit of collectors to look for fossils only in the Coal-measure shales, to the neglect of the ironstone nodules, may account for the paucity of specimens found in other coal-fields.

The other species, *Palæoxyris carbonaria* (Schimper) and *Palæoxyris prendeli* (Lesq.), seem, on the contrary, to be extremely rare in this area, and, when found, they are usually associated with quantities of *P. helicteroides*.

Vetacapsula cooperi (Machie & Crocker)[1] must still lay claim to being an extremely rare fossil. This genus is not restricted to a definite horizon in Derbyshire and Notts Coal-fields, but has been found to range from between the Waterloo and Ell Coals at Newthorpe Claypit, downwards to the Kilburn Coal at Loscoe Colliery. Three new specimens have been obtained—two from the Silkstone Coal and one from the Kilburn Coal. One of these, a specimen from the Silkstone Coal of the Calow Colliery, Chesterfield, shows a feature of great interest. When first found the fossil presented the appearance of a very much crushed example; but careful development revealed the fact that the fossil was, in reality, a perfectly normal flattened specimen, and the feature that gave rise to the apparent deformity was the presence of a medial, longitudinal flange, or fin-like structure, which extends along the 'median raphæ', emphasized by the original describer of the genus, dismissed in my former paper as possibly due to crumpling, and again brought into prominence by Mr. J. Wilfred Jackson. It seems now that this 'median raphæ', which appears to be a constant feature in every specimen recorded, may be caused in the ordinary specimens by this flange being torn off, and being left embedded in the matrix of the counterpart. It is also instructive to compare this new-found flange with that described by Mr. Bashford Dean on the egg-case of *Chimæra colliei*.

From the examination of the four specimens in the author's collection and others elsewhere it is becoming more apparent that there are two distinct species included under the name of *Vetacapsula cooperi*. Owing, however, to the at present uncertainty as to their affinities, and to the rarity of their occurrence, it seems best still to keep them under one trivial name and separate them by applying the designation 'forma a' to those specimens in which the pedicle expands suddenly into the body, forming a distinct shoulder in the lower third of the body and giving rise to a 'deformity' or crumpling in that region; and the designation 'forma β' to those in which the pedicle expands more gradually into the body, giving to the specimen an ovate contour, with the 'deformity' or crumpling in the centre.

A curious and interesting feature is seen on the outer edge of all specimens conforming to 'forma β'. Just before the body contracts to form the beak there is found, by examination with the ordinary lens, a minute crenulation or crimping of the edge of the fossil, which may be compared with the markedly rugose lateral webs seen on the egg-cases of *Chimæra colliei*, *Rhinochimæra*, and other Chimæroids.

[1] E. J. Machie, *Geol. and Nat. Hist. Repertory*, vol. i, pp. 79–80, 1865–7.

One fresh specimen of *Vetacapsula johnsoni* (Kidston) has come under notice from the Worsborough open works near Barnsley. It is in too crushed and imperfect condition to show any new features.

A new species of *Vetacapsula* has been recently described by Mr. Good[1] from Pembrokeshire. It is very similar to *Vetacapsula johnsoni*, but is extremely small, measuring only 5 mm. across, whereas *Vetacapsula johnsoni* measures 20 mm.

A new specimen of *Fayolia crenulata* (Moysey) has been discovered lately from a small heap of nodules still remaining from the Shipley Claypit. The former example from Shipley consisted of the middle portion of the organism 11 cm. long; another specimen, doubtfully referred to *Fayolia sterzliana* (Weiss), from the same locality, was evidently nearing its proximal or pedicular termination. The new specimen is of interest mainly because it shows the apex or distal termination, which appears to have been dome-shaped. The chief feature is the marked exaggeration of the crenulate 'collerette' which arises from the junction of the two spiral valves, and which forms a sort of spiral 'corona' round the apex of the fossil, strongly reminiscent of the corona at the summit of the egg-case of *Cestracion philippi*.

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(4) On the Conditions which govern the Transport and Accumulation of Detritus by Wind and Water. By Vaughan Cornish, D.Sc., F.R.G.S., F.G.S., F.C.S.

The author dealt with the conditions of the transport of detritus superficially and in suspension. He pointed out that the rate of subsidence is the constant which best defines the behaviour of a granular material with respect to transportation by currents. He showed how detritus may be classified in three groups according to the value of this constant, these groups being familiar as shingle, sand, and mud, in the case of water-borne material, and gravel, sand, and dust in the case of wind-borne detritus.

It was pointed out that the change of direction of the vertical currents in sea-waves does not occur simultaneously with the change of direction of the horizontal currents, and it was shown that the result of the sequence of the changes is to endow waves with a shoreward action upon shingle and the coarser kinds of sands independently of any motion of translation in the water.

In tides also, rise does not commence simultaneously with flow, nor fall with ebb, and the author showed that the sequence of these changes is such as to make the flood tide more effective than the ebb as an agent of littoral drift, apart from any greater speed of current.

Examples were given of the different positions in which deposits of detritus accumulate according to the rate of subsidence of the particles.

An explanation was given of the effect of a change in the inclination of current to the horizontal in sorting heterogeneous detritus, and examples were given for wind-borne material.

[1] R. H. Good, Quart. Journ. Geol. Soc., vol. lxix, p. 266, pl. xxx, fig. 3, 1913.

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(5) On the Correlation of the Leicestershire Coal-field. By Robert Douglass Vernon, B.A., B.Sc., F.G.S.

THE following is a preliminary account of a study in the correlation of the coal-fields of the eastern portion of the great Midland coal basin. The area in question includes the Derbyshire and Nottinghamshire Coal-field in the north, the Warwickshire Coal-field in the south-west, and the Leicestershire Coal-field, which lies midway between the two. It is with the latter that we are here chiefly concerned. The Carboniferous rocks of Leicestershire include Carboniferous Limestone, Limestone Shales, Grits, and Sandstones that have been referred on lithological evidence to the Millstone Grits, and, lastly, the Coal-measures. Such a sequence at once suggests a correlation with the Derbyshire and Nottinghamshire type, but the presence of unusually thick seams of coal which split towards the north favours a comparison of the Middle Coal-measures of Leicestershire with those of Warwickshire. Finally, in the complete absence of the Transition Series and Upper Coal-measures and the presence of a complex fault system, the Leicestershire Coal-field stands quite apart from either of its neighbours.

For the detailed correlation of the Upper Carboniferous of these tectonic basins we have several independent criteria, both physical and palæontological, but strong theoretical objections may be urged against the use of physical criteria alone, and in practice it was found to be impossible to use either the important sandstones or the seams of coal in the correlation even of the eastern and western portions of the Leicestershire Coal-field itself.

The problem was then attacked from the palæontological side. Fossil plants proved of relatively little value in the subdivision of the Leicestershire sequence, because the lowest and the highest plant-bearing horizons both appear to fall within the Middle Coal-measures. The freshwater lamellibranchiata (*Carbonicola* and its allies) were equally unsatisfactory, so that the work finally resolved itself into a search for Marine Beds and an attempt to lay down their outcrops on the 6 inch maps.

Of the three more or less distinct districts into which the Leicestershire Coal-field may be divided, the Central or Ashby area of so-called unproductive measures yielded no fossils, either plant or animal, and the age of the beds, whether Lower or Middle Coal-measures, remains an open question. The Eastern or Cole Orton area presents serious difficulties to the collector, being for the most part a concealed coal-field worked under a thick Triassic cover, and the results obtained were merely of local interest. Attention was finally concentrated on the western or Moira area, where the sequence is more complete than in the rest of the coal-field, and exposures are much more numerous. Many fossiliferous horizons were discovered, which yielded a rich flora, several rare Crustacea, some fragmentary fish-remains, numerous freshwater lamellibranchiata, and above all an abundant marine fauna from several different horizons and many localities. Unfortunately, no indication of the well-known Ganister Coal Marine Bed (Alton Coal of Nottinghamshire) has yet been found in Leicestershire.

The thickest Marine Bed, which also has the richest fauna, occurs in the higher portion of the Middle Coal-measures about 260 yards above the Moira Main Coal; it crops out at many places in the Moira, Swadlincote, Church-Gresley, and Woodville district, and the outcrop has been laid down on the 6 inch scale.

Such mapping is of value, since for want of an index bed it has hitherto been impossible to map any seam of coal above the Main Coal owing to the variable character of the beds in the higher portion of the Coal-measures, and the structure of this part of the coal-field was, therefore, imperfectly understood. Using this Marine Bed as an index bed, we can now fix the position in the sequence of the Moira Sandstones and Grits and of the valuable series of pot, pipe, and fireclays on which the prosperity of this district so largely depends.

The main interest of this Marine Bed is that in stratigraphical position and in faunal contents it is comparable with the Gin Mine Marine Bed of the North Staffordshire Coal-field, with the Mansfield Marine Bed of the Yorkshire and Nottinghamshire Coal-field, and with the Pennystone Ironstone Marine Bed of Coalbrookdale.

The following is a correlation of the Productive Coal-measures of the East Midland Coal-fields, based upon the chief marine transgressions:—

	Yorkshire and Nottinghamshire Coal-field.	West Leicestershire Coal-field.	Warwickshire Coal-field.	
Middle and Lower Coal-measures.	Mansfield Marine Bed.	Pottery Clay Marine Bed.	Doubtful	Middle Coal-measures.
	Strata, 930 feet.	Strata, 750 feet.	Strata, thickness unknown	
	Marine Bed 300 feet below the Top Hard coal.	Marine Bed above the Main Coal.	Marine Bed above the 7 foot Coal	
	Strata, 1,600 feet.	Strata, thickness unknown.		
	Marine Bed above the Alton (Ganister) coal.	Doubtful.	Absent.	

In conclusion, it is shown that in colour, mode of weathering, and other characteristics these Marine Beds are in every way comparable with modern 'Blue Muds'.

(6) On the Stream-courses of the Black Country Plateau. By Henry Kay, F.G.S.

The Black Country plateau is roughly outlined by the 400 feet contour-line between Stafford, Worcester, Stratford, and Burton, and is identical with the anticline of the South Staffordshire Coal-field, plus the north-western parts of Cannock Chase and the Warley–Barr area eastward. On its eastern and western sides are synclinal valleys opening to the Trent and Severn.

It is surrounded by a marginal hill barrier, and has large hill masses at Cannock Chase and the Clent region; while it is crossed by hill ranges from Bushbury to Barr Beacon, from Wolverhampton to the Lickeys, and from Quinton to Birmingham. The surface is thus divided into four interior basins, forming separate drainage areas. Save for the exits from these basins, the margin is broken in two places only. The chief physical feature is the possession of the crucial portion of the Midland watershed, which runs across the plateau from Wolverhampton to the Lickeys, and thence eastward along the southern margin.

Arterial drainage is supplied by the Trent and Severn, the former draining five-sixths of the plateau, and the latter receiving only the southward marginal drainage and that of the Stour basin.

The eastern syncline is occupied by the River Blythe–Tame flowing north. The watershed at the southern end of this valley has retreated northwards for 4 miles in post-Glacial time.

The western syncline was formerly drained towards the Dee, and the head-waters of the Severn were originally around Kidderminster, the Clent range being united with the Enville Hills further west. The principal outlet towards the Dee was by the Church Eaton Water, and the outlet into the Trent below Stafford not then in existence. This syncline is now drained northward by the Penk into the Sow and Tame, and southward by the Smestow–Stour into the Severn. Stream piracy is manifest near Wolverhampton.

Marginal streams are characterized by excessive activity, especially southward, notable examples being the Arrow and the Alne. The Arrow, however, represents the captured head-waters of an ancient river flowing through the Moreton Gap into the Evenlode, the pirate stream being the Warwickshire Avon, a strike river originally confined to the country west of Evesham. The watershed then ran southward from the Lickeys to the Cotswolds, being now represented by a long, narrow promontory reaching into Evesham and by Bredon Hill southward. Internal drainage is confined to the four basins. The Cannock basin has now no trunk stream, its waters uniting near the exit below Cannock to form the Saredon Brook. Glacial modification is much in evidence, the south-eastern portion having formed a lakelet with gorge-like overflow through Walsall. The margin of this basin has twice been broached by marginal streams. The Tame basin is triangular in shape and formed by the union of two basins reaching back to pre-Triassic ages, a large buried stream-course existing at Moxley, whilst a very great valley is traceable upwards through Smethwick, Oldbury, and Blackheath. At this point two buried stream-courses are found, each filled with material transported from the Clent Hills. The inference is that this marked the original source of the Trent, as the Upper Trent Valley appears to be of more recent date.

The Stour basin is likewise a combination. Streams descend south-west from Dudley to Stourbridge, and north-eastward from Clent to Halesowen. They are united by a succession of gorges 4 miles in length. This basin is a remarkable instance of extreme post-Glacial denudation to a depth of 300 feet. The Halesowen streams represent the original head-waters of the river once flowing through Blackheath, Oldbury, and Smethwick.

The Rea basin possesses three eastward-flowing streams successively diverted N.N.E. through Birmingham by a stream working back along the Rea fault. Two of these were captured in pre-Glacial time, the third in consequence of glacial lakelet overflow. The present thrice-notched ridge at King's Heath represents the pre-Glacial land surface. The Middle Cole Valley is wholly post-Glacial. The Lickey anticline has undergone elevation since the initiation of the Rea streams—i.e. in post-Tertiary time. It is crossed by three waterworn gaps excavated *pari passu* with this uprise. The southernmost of these now drains into the River Arrow.

The Warley–Barr area is a region of Tertiary uplift, across which rivers occupying the old pre-Triassic valleys have excavated deep channels. All other streams in this area are very youthful.

Conclusions.—The Trent drainage area has been subjected to excessive piracy and has steadily suffered loss. Its sole gain is that of the Penk at the expense of the Dee. The northern drainage is consequent on the formation of the South Staffordshire anticline, regarding the age of which it bears notable evidence. Speculations as to the former north-west extension of the Thames drainage must therefore be abandoned on reaching the area under consideration.

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(7) On some of the Basement Beds of the Great Oolite and the Crinoid Beds. By Edwin A. Walford, F.G.S.

SOWERBY, in vol. i *Mineral Conchology*, describes a Brachiopod now known as *Rhynchonella concinna*. It is figured on T. lxxxiii, 6 from Aynhoe in Northamptonshire. A note on a quarry in the Great Oolite made by the writer in 1883 fixes probably the source of Sowerby's shell—

Aynhoe Allotments Quarry.

		ft.	in.
1.	Humus	1	3
2.	Whitish Marl	1	3
3.	Marl crowded with *Rhynchonella concinna*, *Ostrea Sowerbyi*, *Natica*, *Modiola*, *Pholadomya*	2	6
4.	Shelly Limestone, false-bedded	1	9
5.	Grey Marl	2	1
6.	Limestone, whitish: top course	1	6

The Geological Survey found its stratum to be a convenient line of demarcation, as it rested upon a base of limestone graduating into the Stonesfield Series.

The discovery of other strata on the borders of East Oxfordshire and West Oxfordshire necessitates the division of the Great Oolite and the separation of the new beds proposed to be classed as Sub-Bathonian. The old survey lines are thus sustained. The sequence suggested is as follows:—

Upper Great Oolite.—1. *Terebratula maxillata* beds. 2. *Calcaire à Echinodermes.*

Lower Great Oolite.—1. Striped Limestones. 2. *Rhynchonella concinna* beds. 3. Stonesfield Slate.

Sub-Bathonian.—1. Striped Limestone and Crinoid beds. 2. Neæran Series. 3. Striped Crinoid Marls. 4. Chipping Norton Limestones.

The new railway (Aynhoe and Ashendon) is cut along the divide between the Cherwell and Ouse Rivers. The missing Sub-Bathonian Series of the West lands were brought to view. Prominent there were White Calciferous Limestones and Striped Marls and Limestones. The author found the chalk-like limestone to be crowded with the decayed heads of large crinoids of which it was made. Above it passed into a blue crystalline limestone, here and there; a packed mass of the brachial joints of the crinoids. At the base of all was the stratum of black vertical stripes (the striped beds), the place of crinoid column and rootlets filled with carbonaceous granules from dark beds above. The beds are now known to be marine, not estuarine, as previously described. Sections of the chalk-like limestone showed a pavement of discs of the crinoid (*Apiocrinus*) calyx.

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(8) On the Structure of the Lias Ironstone of South Warwickshire and Oxfordshire. By Edwin A. Walford, F.G.S.

THE ironstone of South Warwickshire and North Oxfordshire is got wholly from the Middle Lias. The Northamptonshire ironstone of the Inferior Oolite may be traced in the Burton Dassett Hills, where it passes into a useless sandstone.

Beds of the Middle Lias stone are seen in the quarries packed with curved and interlacing stems something like masses of annelid tubes. They lie upon the bedding plane. Other beds of the fine pentangular and smaller ossicles of the Crinoidea range between. More rarely the round columnar stems of forms like *Apiocrinus* are found.

The author infers that the sea floor of the Middle Lias was a tangle of crinoid growth, stage above stage. The Crinoid sea appears to have spread through the Midlands into Yorkshire. Occasionally are phases of invasion or dominance of shells of Brachiopoda. Beds of *Rhynchonella tetrahedra* and *Terebratulæ* are interspersed in the 25 feet of the ferro-crinoid rock-bed.

The quarries and sections in the neighbourhood of Banbury show the several phases described.

In the Nodule Bed at the base of the Ironstone Series (zone of *Spirifer oxygona*) crinoidal conditions appear in segments and stem casts, mingled with large mollusca. Microscopic sections present plates and segments of Crinoidea mingled with ferruginous Oolitic grains of large size and fox-brown colour.

The superimposed bed, the Best Rag, has in sections smaller Oolitic grains of olive-green iron carbonate with ovoid calicular plates of crinoids.

The Top Rag, a grey-green compact stone, is a tangle of crinoidal and other remains more or less broken and converted into Oolitic iron granules.

The Road Stone, the higher beds, shows its organic structure mainly destroyed and converted into the ordinary red oxide.

In 1896 I placed a short study on the making of the Middle Lias Ironstone of the Midlands before the Iron and Steel Institute, which appeared in their *Proceedings*.

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(9) Notes on the Flora and Fauna of the Upper Keuper Sandstones of Warwickshire and Worcestershire. By L. J. Wills, M.A., F.G.S., and W. Campbell Smith, M.A., F.G.S.

A GROUP of sandstones associated with green shaly marls have been shown by Dr. C. A. Matley to form a more or less continuous belt in the Keuper Marls in Warwickshire, and to lie about 120 to 160 feet below the Rhætic. At the same horizon similar beds form an almost unbroken outcrop through Ripple, Longdon, Pendock, and Eldersfield in South-West Worcestershire, and were probably once continuous with the sandstones of Inkberrow and Callow Hill, near Redditch.

Of the constituents, the thin-bedded sandstones are fine-grained, ripple-marked, and characterized by the presence of much calcareous matter and abundant rhombs of dolomite. The thicker-bedded sandstones consist mainly of grains of quartz, with felspar and the usual assemblage of heavy minerals in well-rounded grains; of these garnet is the most conspicuous. Close to the base of the group there is frequently a conglomeratic bed ('bone-bed'), composed of fragments of green marl, plants, bones, and teeth. Shales and steinmergel may occur with the sandstones.

We are able to describe for the first time from the English Trias examples of the foliage and scales of the female cone of a *Voltzia*, closely resembling *V. heterophylla*, of the Bunter of the Vosges, and to record new occurrences of *Voltzia*, *Schizoneura*, *Carpolithus*, and, possibly, *Yuccites*.

The plants are associated with indeterminable teeth and bones of Labyrinthodonts, and with fish-remains, which are abundant in the 'bone-bed' and very rare at higher horizons.

Fish-teeth, hitherto described as *Acrodus ? keuperinus*, are widely distributed, and prove, on microscopic examination of their internal structure, to be referable to *Polyacrodus* (Jaekel). Dorsal-fin spines and cephalic spines associated with these teeth probably belong to the same genus.

Teeth similar to *Phœbodus brodiei* have been found at Knowle. *Phœbodus*, *Semionotus*, and *Ceratodus* have all been previously described from these beds.

Cestraciont remains allied to *Polyacrodus keuperinus* are especially abundant in 'bone-beds' at the base of the Lettenkohle in Germany, and its presence may be regarded as evidence of estuarine conditions. *Ceratodus*, on the other hand, occurs frequently in the Rhætic, a deposit usually accepted as marine, but its only living ally inhabits some rivers in Queensland.

We have found *Thracia ? brodiei* at Shelfield. This lamellibranch was described by Mr. R. B. Newton as a truly marine form, but it is only represented by rather obscure casts.

Estheria minuta, a form that is probably never truly marine, is practically ubiquitous, and occurs in both shales and sandstones.

The fauna and flora is thus seen to be a restricted one, though many specimens have been found, and their testimony on the origin and age of the deposit is inconclusive.

If we may judge from the lithology, the conditions which governed the formation of the 'skerry-belts' of Nottinghamshire and Leicestershire—namely, the arrival of floods of fresh water—probably acted more persistently in the area under consideration, as a result of its greater proximity to land. For not only are the beds very similar to the 'skerries', but in the 'bone-bed' or marl conglomerate we have positive evidence of littoral conditions.

Thus we are not dealing with a pre-Rhætic incursion of the sea, but with a littoral facies of the Keuper Marls, formed where the water was at times sufficiently fresh to support a small fish-fauna and in sufficient motion to move coarse sediments.

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(10) On the Fossil Floras of the South Staffordshire Coal-field. By E. A. Newell Arber, M.A., Sc.D., F.G.S.

THE rich series of floras of the South Staffordshire Coal-field has suffered much unfortunate neglect in the past. Several collections have, it is true, been made from time to time, but with very few exceptions they have never been described, and some of them are without proper records of locality and horizon. For such trustworthy records as exist we are chiefly indebted to Dr. Kidston and to his memoir published as far back as 1888. The number of species, the exact locality and horizon of which are recorded, is at present as follows:—Keele Series 16, Halesowen Sandstone Series 0, ? Brick Clay Series (Old Hill Marls) 8, Productive Measures 27.

For some time past I have been endeavouring to extend our knowledge of the fossil floras of this coal-field, and I have been fortunate in receiving the active co-operation of several geologists resident in Birmingham and the neighbourhood, who have most kindly formed collections from particular areas, and forwarded the specimens to me for examination and description. In this way the material which I have myself been able to collect has been greatly extended. My thanks are in particular due to Mr. H. Kay, F.G.S., Mr. W. H. Foxall, F.R.G.S., Mr. W. H. Hardaker, M.Sc., and Mr. L. Jackson for their enthusiastic co-operation.

Attention has been chiefly concentrated so far on the floras of the Brick Clays, and of the lowest beds of the Productive Measures on or about the horizon of the Bottom Coal. A considerable number of species have been obtained from both horizons, of which some are new records both to the coal-field and to Britain. This work is still in progress. Information has also been obtained as to the horizon and localities in which the petrified specimens, long known from this coal-field, occur, such information having been lost for many years past.

In addition the first fossil plants from the Halesowen Sandstone Series have been unearthed by Mr. Kay, and here again both petrifactions and impressions occur.

It is hoped that in course of time it will be possible to trace the floras systematically from the lowest to the highest beds of the Coal-measures of this coal-field. The material, however, has to be obtained as opportunity offers, and this preliminary note is intended merely to indicate the present progress of the work.

(11) On Systems of Folding in the Palæozoic and Newer Rocks. By G. Barrow, F.G.S.

In a paper published by the Geologists' Association the author has given a brief outline of the nature of the crystalline area of the Highlands and shown that it consists of three great lenticular masses of thermally altered rocks. It is further shown that the outer and uncrystalline margins of these masses all trend roughly north-east and south-west. The best known is that forming the south-eastern margin of the crystalline area, which the author has followed, where present at the surface, almost the whole distance from Stonehaven, on the east coast of Scotland, to Omagh in the north of Ireland. Recent work suggests that this margin is also present on the west coast of Ireland.

This outer margin of crystallization is not confined to Scotland; it is also present in Anglesea, where the margin of the crystalline massif is seen along a portion of the Menai Straits. It also occurs in the Isle of Man, where the old rocks are identical with those of the lower aureoles of thermometamorphism in the Southern Highlands. In both cases the trend of this outer margin is the same—north-east and south-west. Wherever this margin can be examined it has been found to be a great line of resistance, and the folding in the adjacent palæozoic, and, at times, even newer rocks, is found to be parallel to it; it is in fact the cause of the strike of the folding; under earth-stresses the softer rocks have buckled up against a great resisting crystalline mass.

Thus, strictly speaking, there is no such thing as a Caledonian Movement; there are a series of resisting masses with parallel margins; the folding in North Wales is determined by the Anglesea Archæan Rocks; Caledonia has nothing whatever to do with it.

If, now, we turn to the area in the south of Britain, we find another system of folding; this, too, the author believes to be due to a similar cause. The outer margin of the old crystalline rocks in Cornwall seems to be roughly east and west; it certainly is not north-east and south-west. It now remains to do in the north-west of France what the author has done in North Britain—i.e. to trace out the outer margins of crystallization and prove that the so-called Hercynian system means simply that the boundaries of the resisting crystalline masses, against which the newer rocks buckle up, now trend east and west. If these facts are once grasped we have an explanation of the local departure of the strike of the folding in the north of England; the lines of resistance locally depart from their usual trend and the subsequent folding does the same.

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(12) On the Spirorbis Limestones of North Warwickshire. By G. Barrow, F.G.S.

The typical Spirorbis limestone is a rather compact rock, usually grey and generally containing the small fossil *Spirorbis carbonarius*. The number of these varies greatly; at times several specimens may be seen in one fragment; often it is difficult to find any, and, so far as experience has gone at present, they are never abundant in this area. Though the dominant colour is grey, the rock is often buff and occasionally almost white.

The purest form of Spirorbis limestone occurs in masses of very variable size. The largest and most persistent bed is the Index limestone, which occurs roughly about 100 feet down in the Halesowen or Newcastle Group. This has often been confused with another and less persistent bed, lying about 100 feet further up and close to the base of the Keele Group. Other and less persistent bands have been met with in the Keele Group, notably by Mr. Cantrill. In addition to these distinct beds, which can often be traced for some distance at the outcrop, if the ground be free of drift, there are lenticles varying in length from a few yards to a few inches, and at times only scattered nodules. These smaller patches were found during the great drought, when the old marl pits in the Halesowen Group were completely dried up. Advantage was taken of this to clean the pits out, laying the rock sides bare, when these minor occurrences of the limestones were exposed.

The limestones seem to have been built up of a series of films or layers, resulting from the evaporation of shallow sheets of lime-bearing water. When dried the film appears to have been cracked and more or less broken up, but re-cemented by later deposits of identical material; this in turn became broken up and re-cemented. The process was repeated till a bed several feet thick was at last accumulated. The whole rock thus comes to have a clean sharp fracture, though its fragmental character is easily seen on a freshly fractured face. In this form, best shown by the Index limestone, there is a minimum of material other than lime brought into the deposit. A rough test of the brecciated original fragments shows the limestone to be nearly pure and containing about 95 per cent of carbonate of lime.

From this we pass to the type containing small fragments of other material, such as marl, and the cementing matrix is not merely calcite, a considerable proportion of mud and sand being present. In this the limestone fragments are somewhat rounded, having been transported for short distances. At times the fragments are locally heaped up and the bed attains a quite abnormal thickness. The band at or near the base of the Keele Group shows this character in the cutting of the mineral railway above Kingsbury; the fragments have been heaped up till it has locally attained a thickness of 10 feet.

The extreme type is really a cornstone, or a sandstone more or less crowded with rolled fragments of Spirorbis limestone. It is doubtful in this case if any of the rounded fragments are formed in situ; the whole rock seems to have been the result of flood action tearing up a deposit cracked by drying and transporting the fragments for some distance.

There is strong evidence to support the view that two at least of these limestones were formed over a large area; the Index has rarely been removed completely by this process; the one next above often has. How far the less persistent beds have been locally removed by subsequent erosion is at present an open question.

This mode of origin of the more impure, possibly of all the limestones, is supported by the character of the sandstones. These at their base often contain abundant pellets of marl, which from their form appear to have been sun-dried and so rendered sufficiently coherent to be capable of transportation for short distances without losing their cuboidal form. The phenomena suggest formation in shallow water, during a dry epoch, subject to sudden or periodical floods.

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(13) THE GEOLOGY OF THE DISTRICT BETWEEN ABEREIDDY AND PENCAER, PEMBROKESHIRE. By A. HUBERT COX, M.Sc., Ph.D., F.G.S., and Professor O. T. JONES, M.A., D.Sc., F.G.S.

IN an introductory paragraph the authors referred to the work of previous observers, namely, Hicks, Reed, Elles, and Elsden, and to the visit of the Geologists' Association during Easter, 1910, when results were obtained which suggested that this area required re-investigation. Examination by the authors has proved that the apparent sequence is extremely complicated by strike-faulting, and instead of Llandeilo and Bala rocks as previously supposed, Arenig and even Cambrian rocks form large areas of the coast.

Part I. Abereiddy Bay to Pwll Strodyr (A. H. Cox).

The ground is occupied by the under-mentioned beds, the stratigraphical order of which is, so far as known, as follows :—

BALA	Limestone of Eastern Quarry, Abereiddy = Mydrim Limestone of Carmarthenshire.
LLANDEILO	Lower Dicranograptus Shales = Hendre Shales of Carmarthenshire.
LLANVIRN	Didymograptus Murchisoni Shales. Didymograptus Murchisoni Volcanics (including the Abereiddy Ash, and Llanrian lavas). Didymograptus bifidus Shales.
ARENIG	Tetragraptus Beds—dark slates. Porth Gain Beds—grits and slates with *Orthis calligramma*, var. *proava*. Abercastle Beds—sandy mudstones with *Ogygia selwyni*, etc.
	? gap.
DOUBTFUL AGE . .	Castell Coch Beds—cleaved blue-black mudstones. Ynys Castell Beds—siliceous mudstones and cherts. Ynys Castell grit and breccia.
	? break.
LINGULA FLAGS . .	Flags and laminated quartzites with *Lingulella davisii*.
DOUBTFUL MENEVIAN.	Slates near Abercastle with *Agnostus* sp.

The 'Middle Llandeilo' of Hicks' classification has been found to include the Lower Dicranograptus Shales and the succeeding limestone; that is, actually more than the Llandeilo formation as now defined. The 'Upper Llandeilo' includes various Lower Llanvirn and Arenig beds; the affinities of the other rock-groups are briefly discussed in the paper. Lingula flags occupy much of the adjoining inland district.

References are made to certain "intrusive rocks and their relation to the adjoining sediments". The detailed mapping of the area is now in progress.

Part II. Pwll Strodyr to Pencaer (O. T. Jones).

The following rock-groups are represented in probable descending order:—

LOWER OR MIDDLE ARENIG	Pwll Deri Slates . . .	Cleaved dark slates with extensiform graptolites.
? LOWER ARENIG . .	Aberbach Quartzite Group probably equivalent to the quartzites of Trwyn Llwyd and possibly of Pwll Strodyr.	Quartzites with thin dark shales.
LINGULA FLAGS . .	Mynydd Morfa Group.	
DOUBTFUL AGE . .	Pwll Crochan Group . .	Dark slates with obscure fossils probably Menevian or Upper Lingula Flags.
? SOLVA	Llech Dafad Group . .	Quartzites, green and purple sandstones; obscure fossils.

The age and relationships of the various groups are briefly discussed, and reference is made to certain intrusive rocks which occur among the lower groups.

In view of the great thickness of some of the groups and of the bearing of their age upon the igneous rocks of Pencaer and Strumble Head it is proposed to map the area in detail.

REVIEWS.

I.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND THE MUSEUM OF PRACTICAL GEOLOGY FOR 1912. 8vo; pp. iv, 101, with 1 plate and 4 text-illustrations. London: printed for H.M. Stationery Office, 1913. Price 1*s*.

IN this memoir, as usual, there will be found much to interest all geologists, whether their special studies are among the Archæan schists or on succeeding geological systems up to the time when Palæolithic Man occupied the country. In England and Wales field-work has been carried on in three districts: Denbighshire, Warwickshire and Staffordshire, and London with the south-eastern counties. In Scotland the districts comprise the West Highlands, North and Central Highlands, Kilmarnock in Ayrshire, and South Lanarkshire.

Attention is called to the occurrence in Ben Armine Forest, Sutherland, of an altered peridotite, which is in contact with gneisses of Lewisian type and granite intrusions, and was probably intruded prior to the movements which caused the schistosity of the rocks. The subsequent remarkable effects of granitization are described.

The mapping of some of the older Palæozoic rocks on the western borders of the Denbighshire Coal-field has been revised, and it has been found that the Tarannon Shale does not rest unconformably upon the Ordovician, but that the Llandovery Beds are present, and no evidence of unconformity locally exists. Some modifications have been found necessary in the groupings of the strata classed as Millstone Grit and Lower Coal-measures, and an unconformity has been proved at the base of the Upper Barren Coal-measures in the Denbighshire district. In Lanarkshire evidence of unconformity in the Millstone Grit has been observed. A large tract near Tamworth, regarded on the old geological survey maps as Keuper Sandstone, has now been ascertained to consist of the Keele Beds or Upper Red Coal-measures. Some questions concerning the upper limit of the Keele Beds have yet to be solved.

Notes are contributed on the Lias and Cretaceous rocks of Mull (West Highland district), and particulars, illustrated by three maps, are given of the Tertiary igneous rocks. The discovery is recorded of numerous small hexagonal plates of blue corundum (sapphire), with other minerals, in an igneous matrix that consists of andesitic felsite and trachytic granophyre or syenite, with included blocks of baked sandstone and shale.

In the London district the transitional clays, loams, and sands, between the mass of London Clay and the Lower Bagshot Sand, have been separately mapped as the "Claygate Beds". Descriptions are given of the glacial and later drift deposits in the various districts.

In the Appendices there is a short article "On some Palæolithic Gravels near Swanscombe, Kent", by Mr. Reginald Smith (of the British Museum) and Mr. Henry Dewey (of the Geological Survey). They give results of a careful personal study of the successive Pleistocene deposits in the Barnfield Pit, about half a mile north-west of Swanscombe Church. Here, resting on the Thanet Sand, the top of which is about 90 feet above O.D., is a series of gravels, sands, and loams, about 25 feet thick, that are usually described as forming the 100 foot terrace. For about three weeks the authors employed two gangs of men, and examined every spadeful of material dug away in order to ascertain the nature and sequence of the flint implements. Their results may be summarized as follows:—

Upper Gravel . .	Several flakes and one good implement, "but further evidence is required as to the horizon."
Upper Loam . .	Said to contain white patinated ovates.
Middle Gravel . .	More advanced forms, with one or two ovates of St. Acheul character. Palæolithic implements of Early Chelles type.
Lower Loam . .	No implements.
Lower Gravel . .	Numerous flint flakes and some roughly cylindrical flints chipped at one end into a point or chisel-edge. Comparable with the Belgian type named after Strépy in Dr. Rutot's system.

It is regarded as not improbable "that the Middle Gravel represents the whole of the Chelles period and the transition to St. Acheul".

Records of borings at Lowestoft, Henlow in Bedfordshire, and Batsford in Gloucestershire, are communicated by Dr. A. Strahan. Those of Lowestoft and Batsford are specially important. At Lowestoft[1]

[1] Boring commenced 1902, not 1912.

the Chalk was proved to be 1,050 (possibly 1,055) feet thick; and it is interesting to note that at Norwich in Colman's Well a thickness of 1,152 feet of Chalk was proved, but not quite the full local thickness, there being some 35 or 40 feet of Chalk in the bordering hills not passed through. The occurrence of 11 feet of Upper Greensand is also of interest, as this formation (6 feet thick) was also recognized in the Norwich boring. Below the depth of 1,627 feet at Lowestoft, beneath Gault and Lower Greensand, there were 205 feet of pale mudstones, regarded as "Cambrian or Ordovician, probably the former". They yielded fragmentary remains of *Lingula* and *Orbiculoidea*. Water was obtained from the Lower Greensand, but the quality was medicinal.

At Batsford, or Lower Lemington, near Moreton-in-the-Marsh, the boring was carried out in 1901–4 by a Coal Syndicate. Coal-measures were reached at a depth of 1,021½ feet, but at the depth of 1,546 feet Silurian rocks were encountered. The Coal-measures were not of productive character, but it is possible that productive beds occur in the vicinity in proximity to Silurian rocks, as they do in the South Staffordshire Coal-field.

Another article of practical importance is on "The Copper Lodes of Inveryne and Kilfinan, Argyllshire", by Mr. C. T. Clough.

II.—Mines and Mining in the (English) Lake District. By John Postlethwaite, F.G.S., Assoc. M. Inst. M. E. 3rd ed. 8vo; pp. xii, 164, with geological map, 15 plates, and 29 other illustrations. Whitehaven: W. H. Moss and Sons, Ltd., 1913. Price 3*s*. 6*d*. net.

The first edition of this work, issued in 1877, was favourably reviewed by John Morris in the Geological Magazine for 1878, p. 317; and a second and enlarged edition was published in 1889. In the present work much has been added, references being inserted to the later geological publications, together with lists of fossils and illustrations of a number of them. It would be well in a future edition to have the aid of a palæontologist in dealing with the names of species and the use of capital letters, etc. The main object of the work is, however, to describe the minerals and the mines, a practical and scientific subject with which the author is especially qualified to deal; and he has now added a considerable number of plans and sections of mines and veins, and some excellent views of quarries. Historical accounts of the coal-mining in Cumberland, and of the iron-mining in Cumberland and Furness, are given; and a synopsis of the State Papers relating to the mines in Newlands and the Smelting Works at Keswick (1547–80) has been appended. There is unfortunately no general index, and the illustrations are not systematically numbered; but the table of contents is full, and may suffice for the many who will appreciate the copious practical information.

III.—The Calvert Boring.

THE interesting and important record has now been published by Dr. A. Morley Davies and Mr. John Pringle (Quart. Journ. Geol. Soc., lxix, p. 308, 1913) on the strata proved in two deep borings at Calvert Station, on the Great Central Railway, in North Buckinghamshire. It exemplifies the need, expressed by Dr. Strahan in his Address to the Geological Society in February last, "that registration of deep borings in a Government Department should be made compulsory." Readers of the *Daily Mail* (October 18, 1911) will have been struck with the announcement, printed in bold type, of "Coal within 50 miles of London", and with the advertisement of "The Bucks Coalfields Syndicate, Limited". It appears that the notion that coal occurred was based on the fact that inflammable gas, termed 'coal gas', was encountered below depths of 380 and 443 feet. This was "taken as an evidence of the possible existence at a shallow depth of a deposit of bituminous coal"; and in some newspapers the statement was made that coal-seams had been struck at a depth of 530 feet. The presence also of "mottled red sandstone" was referred to as "very promising for coal at a shallow depth". The mottled beds are now shown (in the paper above-mentioned) to be stained Tremadoc shales (Cambrian, 443 to 1,398 feet); and they are overlain directly by Lower Lias. It is suggested, however, that the staining might be due to a former covering of Triassic strata. The Calvert gas, which is stated to resemble that obtained from Wigan Cannel-coal, occurred below the base of the Lias, and Dr. Davies and Mr. Pringle mention as a possibility that the gas "may have leaked into porous Triassic strata from underlying Coal Measures, possibly at some distance to the west or north-west".

IV.—Diffusion in relation to the Structure of Agates, etc.

Geologische Diffusionen. By R. E. Liesegang. pp. viii + 180, with 44 figures in the text. Dresden and Leipzig: Theodor Steinkopff, 1913.

GEOLOGISTS interested in the structure of agates, concretionary nodules, and similar objects, should not fail to read Dr. Liesegang's extremely fascinating book. Recent chemical work on diffusion has thrown quite a novel light upon the possible cause of the markings characteristic of such structures, but may not be generally known to geologists, because some of the journals in which many of the original papers appeared do not usually circulate among them. The author has therefore done excellent service by bringing together the somewhat scattered literature on the subject, and showing how closely the results obtained in the laboratory parallel the phenomena actually met with in nature. A valuable and important feature of the book consists of the extensive series of experiments on diffusion which is interwoven in the text to illustrate the particular points dealt with. The salts and materials used in them are all easily procurable, and the careful explanations render it easy to repeat any of the experiments.

The scope of the book is comprehensive in character. It opens with a discussion of diffusible substances, the geological media which admit of diffusion, and the general characters of diffusion; the various types of structure are then treated in detail. The author shows that diffusion has been responsible, moreover, for the alterations that have sometimes occurred in ore-deposits, and for the formation of certain pseudo-fossils, such as, for instance, the once famous *Eozoon canadense*. Two indices, of names and subjects, which bring the book to a close, add to its usefulness.

V.—Determinative Mineralogy with Tables. By J. Volney Lewis. 8vo; pp. v + 151, with 68 figures in the text. New York: J. Wiley and Sons, 1913. Price 6*s*. 6*d*. net.

THIS book is designed to meet the needs of students and of mining engineers, and treats not only of minerals of economic importance but also of many of the rarer species; altogether 380 minerals are included.

In the text we find a brief account of the apparatus, reagents, and methods to be used in 'wet' and in 'dry' tests, and of the principal reactions of the elements. The simple forms of crystals are enumerated and illustrated by fifty-seven figures of various minerals; for an explanation of the face-indices and for other details the reader is referred to textbooks. There is a good glossary of technical terms, and a table of the elements with their atomic weights.

The tables are based very largely on those of Brush and Penfield, but are modified and much condensed; the relative importance of the minerals is indicated by the type in which the names are printed. The determinations are made to rest almost wholly on chemical tests, and no mention is made of the optical properties of minerals. Tables for the determination of rock-forming minerals, on the other hand, commonly neglect the chemical and appeal only to the physical properties. Now that the optical properties of so many minerals are well established, and the use of the petrological microscope has become so widespread, a combination of the two types of tables should be quite possible, and any determinative mineralogy which does not seek to combine the two must be considered a little behind the times.

W. C. S.

VI.—United States Geological Survey.

1. Bulletin 502. The Eagle River Region, South-Eastern Alaska. By Adolph Knopf. pp. 61, with 3 figures in the text and 5 plates (including 3 maps). 1912.

THE area, which has been mapped on the 1 inch scale, embraces a third of the Juneau gold belt of South-Eastern Alaska.

Three large glaciers come down from the Coast Range to within 100 feet of sea-level: they are shown to be retreating. There is evidence that at one period the country was glaciated to 3,400 feet above sea-level, the main ice-stream flowing south-east down the Lynn Canal. The absence of hanging valleys supports the idea that the fjords of this area are due, not to glacial erosion, but to the drowning of a drainage system only slightly modified by glaciation.

The whole of the area between the Coast Range and the coast is occupied by a group of slates and greywackes known as the Berners Formation, probably of late Mesozoic age. These are intercalated with volcanic breccias, tuffs, and augite melaphyres. The Coast Range itself consists of quartz-diorite, which is regarded as of late Cretaceous age. The slates become metamorphosed into schists in the neighbourhood of the quartz-diorite, which itself is markedly gneissose at its margins.

The gold belt is contained wholly within the slates; there are no prospects in the schists or in the quartz-diorite. Ore-bodies occur either as stringers, fissure veins, or occasionally as mineralized dykes.

The dykes belong to a group of minor intrusions of uncertain age, and include diorites, albite diorites, lamprophyres, and gabbros. Their mineralization usually takes the form of intense albitization. Another frequent result is the production of abundant apatite in the altered wall-rocks. Some of these mineralized dykes carry low-grade gold ores, which indicates a magmatic origin for the gold deposits in this area.

Pillow-lavas are recorded at one locality, and their occurrence in an area in which albitization is so prominent a feature would suggest affinities with the spilitic facies. However, the pillow-lavas appear to consist of augite with only a little interstitial material of low refractive index and to belong to the augite melaphyre series of the Berners Formation, whereas the albitization takes place in dykes probably younger than the quartz-diorite of the Coast Range.

The bulletin contains details of the gold prospects in the area, and the geological work has done much to show in what directions fresh ore-bodies should be sought.

2. Bulletin 503. Iron-ore Deposits of the Eagle Mountains, California. By E. C. Harder. pp. 81, with 4 figures in the text and 13 plates (including 6 maps). 1912.

SITUATED in the waterless desert of South California, and some 40 miles from the nearest railway, the Eagle Mountains had been visited only by hasty prospecting parties until the district was surveyed in 1909. This survey located deposits of very pure iron-ore, and it is estimated that about fifty million tons of good ore are available in the northern part of the range. It is thought that the establishment of blast furnaces and steel plants in South California will have for its immediate result the development of these Eagle Mountain ores.

The geological structure of the northern part of the range is that of an oval dome. The centre is occupied by a small outcrop of gneiss and schist; these are surrounded by a series of quartzites and schistose arkose, overlain by a second quartzite with interbedded dolomite lenticles. Into these beds two large sills of quartz-monzonite have been intruded, causing the metamorphism of the quartzites and dolomite. It is in the dolomite horizons and in the surrounding rocks that the iron-ores have been formed. Five types of deposit are recognized: (1) beds and irregular masses of hematite representing nearly complete replacements of dolomite; (2) layers of hematite in crystalline dolomite; (3) small replacement deposits in sediments at the contact of minor quartz-monzonite intrusions; (4) veins in quartzite; and (5) veins in quartz-monzonite. The first type includes quite 80 per cent of the ore in the district. The ore is now in the form of hematite, but the occurrence of pseudomorphs shows that magnetite and pyrites were the original minerals formed by the replacement. A consideration of the ore-bodies and of the associated rocks shows that they result from the replacement of dolomite by ore-bearing solutions of deep-seated origin: the replacement followed the intrusion of the quartz-monzonite sills, but it preceded certain minor intrusions of aplite, quartz-diorite, and soda-syenite-porphyry.

No fossils having been found, nothing is known of the precise age of the quartzites or of the periods at which the intrusions took place.

3. Bulletin No. 530 (1913) consists of "Contributions to Economic Geology (Short Papers and Preliminary Reports). Part I.—Metals and Non-metals except Fuels". Part II, on "Mineral Fuels", was noticed in the Geological Magazine for July (p. 322). In the work before us there are reports on gold, silver, copper, lead, zinc, iron, manganese, aluminium ores, and on some rare metals such as vanadium, carnotite, etc. There are notes and bibliographies on clays, fuller's earth, building stone, gypsum, glass-sand, asphalt, abrasive materials, phosphates, mineral paints, sulphur, graphite, etc.

Bulletin No. 537 (1913) is on "The Classification of the Public Lands", by Mr. George Otis Smith and others. It contains accounts of the laws relating to agricultural, mineral, coal, and other lands; and of the methods of classification of lands and their valuation in reference to various minerals, water-power and reservoir sites, public water reserves, etc. It should furnish useful information and suggestions to the many owners and land-surveyors now concerned in this country in the valuation of estates.

4. Water-supply Paper No. 259 (1912), by Messrs. M. L. Fuller and F. G. Clapp, deals with "The Underground Waters of South-Western Ohio", containing a general description of the topography and geology, and special accounts of the geology and water prospects of each county. The chemical character of the waters is discussed by Mr. R. B. Dole, who considers the suitability of various waters for domestic, industrial, and medicinal purposes, likewise the physical qualities of waters, the suspended mineral matter, the growths of microscopic plants, and the questions of purification and softening. No. 293 (1912) is on the "Underground Water Resources of Iowa", a voluminous report separately printed also by the Iowa Geological Survey (see Geol. Mag. 1913, p. 226). No. 297 (1913) consists of part iii of a "Gazetter of Surface Waters of California", by Mr. B. D. Wood, dealing with the Pacific coast and Great Basin streams. No. 300 (1913), by Messrs. H. D. McGlashan and H. J. Dean, is on the "Water

Resources of California", comprising part iii of Stream Measurements. No. 310 (1913), by Messrs. F. F. Henshaw, H. D. McGlashan, and E. A. Porter, is on the "Surface Water Supply of the United States", being part x, on the Great Basin; and No. 311 (1912), by Messrs. McGlashan and R. H. Bolster, is on the same general subject, being part xi, on the Pacific coast in California. No. 313 (1913), by Messrs. Henshaw and G. L. Parker, is part ii of a report on the "Water Powers of the Cascade Range", well illustrated by maps and diagrams. No. 316 (1913) is a brief account of the "Geology and Water Resources of a portion of South-Central Washington", by Mr. G. A. Waring, who describes the physical features, geology, and agriculture, with accounts of the springs, wells, and systems of irrigation.

VII.—Geological Survey of Western Australia.

BULLETIN No. 42 (1912) comprises "Contributions to the Study of the Geology and Ore-deposits of Kalgoorlie, East Coolgardie Goldfield", part i, by Messrs. E. S. Simpson and C. G. Gibson. The geological structure of the area is described by Mr. Gibson, who states that the original rocks were shales, sandstones, grits, and conglomerates, with possibly interbedded lava-flows, that were deposited probably in pre-Cambrian times on a gneissic or granite floor. The strata were afterwards tilted into highly inclined positions and subsequently invaded by gabbros, diabases, porphyrites, pyroxenites, peridotites, etc. Still later there were intrusions of quartz- and felspar-porphyries, and further earth-movements that gave rise to shearing and faults. Along the shear-planes the auriferous lodes are developed. Accounts are given of the various rocks and mode of occurrence of the ore-deposits. Mr. Simpson then describes the mineralogy of the ore-deposits, the surface and underground waters, and the telluride ores in particular. In a prefatory note the Government geologist, Mr. A. Gibb Maitland, remarks that the results of the researches indicate the probability that the whole of the ore-deposits are likely to persist to the greatest depth to which mining is possible, and that the grade of ore below 2,000 feet may be expected to be as variable as it is above that level. The memoir is well illustrated by maps, views, and microphotographs.

VIII.—Congo.

Annales du Musée du Congo Belge. Géologie, sér. iii, tom. i, fasc. 1: La Faune paléocène de Landana. Par Vincent, Dollo, et Leriche. 4to. Bruxelles, 1913.

ALTHOUGH the existence of these Tertiary beds has been known since 1877, this is the first time their contents have been systematically described and figured. Pechuel - Loesche (1877), d'Andrade (1904), and others have visited the neighbourhood, but beyond fish-remains and some casts of Mollusca few recognizable fossils seem to have been found. The present series have been obtained by M. Diderrich, and show a definite Lower Eocene or passage to Cretaceous facies. The fossils occur in blocks of compact white limestone, recalling white chalk of varying consistency, and are nearly always in the state of casts, the moulds of which retain quite sharply the impression of the ornaments of the shell surface, much the same as in the case of the English fossils from the Chalk Rock. M. Vincent describes the Mollusca, M. Dollo *Podocnemis congolensis*, and M. Leriche some new fishes, *Hypolophites mayombensis*, *Myliobatis dispar*, and a couple of Agassizian species of *Lamna* and *Odontaspis*. Leriche also gives a sketch of the Eocene fish fauna of the west coast of Africa, which confirms the opinion that the general fauna is of early Eocene age. The papers are well illustrated.

IX.—Geological Explorations in Northern Assam.

The Records of the Geological Survey of India, vol. xlii, pt. iv, 1912, contains accounts of two traverses made by geologists accompanying punitive expeditions against the hill tribes of Northern Assam.

E. H. Pascoe, M.A., gives an account and sketch map of "A Traverse across the Naga Hills of Assam from Dimapur to the neighbourhood of Sarameti Peak". The traverse is joined up with earlier mapping by Hayden further to the north. Near Dimapur the Tertiaries are represented by the Tipam sandstones. These are bounded on the east by a reversed fault, bringing in the sandstones and carbonaceous shales of the Disang Series. There is a band of serpentine, derived from gabbro and peridotite intrusions probably of pre-Disang age. The Chimi conglomerate forms an important horizon as it separates the Disang Beds to the west from the Makwari Beds to the east; these latter differ from the Disang Series only in the degree of their metamorphism, which increases eastwards. Blue slates of good roofing quality occur in the Tepe and Tuzu Rivers. The entire absence of limestone between the Tipam Beds and Sarameti Peak is notable. Correlation with other areas is difficult; provisionally the Disang Series is correlated with the Negrais, and the Makwaris with the 'Axials' of Burma.

J. Coggin Brown, M.Sc., accompanied the Abor Expedition of 1911–12. The geological results of this expedition are given in "A Geological Reconnaissance through the Dihong Valley". This was practically untouched ground, and the traverse adds considerably to our knowledge of the mountains bordering Upper Assam. After leaving the alluvial deposits near the mouth of the river, the road crosses Pleistocene gravels resting on Siwalik sandstones containing fragments of lignite. These Tertiary beds are succeeded by carbonaceous shales and quartzites of Gondwana age, associated with a large series of basalts—the Abor Volcanic Series. The junction between Siwalik beds and Gondwanas is probably an overthrust. Above the Gondwanas the route traverses a large series of slates, phyllites, and dolomites, comparable with the Daling and Baxa Beds of the Darjeeling area. These are followed by true mica-schists. There is frequent repetition of similar groups of rocks, which is due to the existence of closely-packed sinuous folds, often overfolded, and having a general N.E. and S.W. trend. Little of economic value was found, the coal being too inaccessible to pay for the working.

X.—Brief Notices.

1. The Hils Basin.—Dr. H. von Koenen discusses the disturbances of the Hils Basin in the Jahresb. Niedersäch. geol. Ver. Hannover, 1913. He describes it as "a basin due to compression, with uptilted margins, its interior being filled with essentially younger beds less strongly influenced by the pressure".

2. Waters of Kharga.—Mr. G. W. Grabham has published in the *Cairo Scientific Journal* (No. 61, vol. v, October, 1911) a paper dealing with the mechanics of wells, the choking of boreholes by deposition, and the exhaustion of strata. This is a reply to Mr. H. J. L. Beadnell's paper, and the whole discussion is interesting and instructive.

CORRESPONDENCE.

A SUPPOSED SUBMERGED FOREST IN SOUTH-WEST SCOTLAND.

Sir,—In your review of Mr. Clement Reid's book on submerged forests you cite the statement that in "Scotland the Neolithic deposits seem to be raised beaches instead of submerged forests". There is what appears to be a submerged forest bed in a small creek called Brighouse Bay, a little west of the estuary of the Dee on the coast of Galloway. It was incidentally noticed in a paper published by the Society of Antiquaries of Scotland in 1875. Some presumably large antlers of (red) deer were recorded as from the "submerged forest". The district is outwardly much like that of South Devon, viz. with low-level beach-platforms, drowned valleys, and what seem to be submerged forest clays. The paper referred to is on the exploration of the Borness Cave, and the mention of the submerged forest is on p. 11 of the reprint. The late Mr. A. J. Corrie and myself were solely responsible for the geological part of the report, and we were guided by the South Devon raised beaches in our identification. It is quite possible we were mistaken. Perhaps some of our readers may be acquainted with Brighouse Bay.

A. R. Hunt.

Torquay.
September 8, 1913.

NOTE ON THE NAME 'CHARMOUTHIAN'.

Sir,—D'Orbigny in 1852 divided the Lias into three stages which he called respectively the Sinemurian, the Liassian, and the Toarcian, and in 1864 Mayer-Eymar proposed the name 'Charmouthian' to take the place of d'Orbigny's Liassian. As pointed out by Mr. W. D. Lang in this Magazine (1912, p. 284), this middle stage of d'Orbigny and Mayer-Eymar included more than has usually been assigned to the Middle Lias in England. I am not now concerned with the grouping of the zones, but with the form of the name which has been adopted by most French geologists in preference to the Pliensbachian of Oppel.

The name is, of course, taken from the little town of Charmouth in Dorset, near which the Middle Lias is well exposed in the cliffs, but it is unfortunate that Mayer-Eymar should have tried to latinize such a name as Charmouth without making any inquiry as to its ancient form. It is a recognized custom or rule that when such names are derived from those of places or districts they are based on the Roman name if there was one, or on the earliest known form of the name.

I am informed by Dr. H. C. March, F.S.A., that Charmouth is generally believed to be the place called *Carrum* in the Anglo-Saxon Chronicle, which records a battle fought there by King Egbright against the Danes in A.D. 833, and this seems to be the earliest mention of the place, which was never a port of any importance. All the editors and commentators identify Carrum with Charmouth, and it is this ancient form of the name which should be taken as the basis of a stratigraphical term and not the uncouth modern name of Charmouth. I think, therefore, that if our French colleagues continue to use a name taken from this place they should substitute *Carrumian* for Charmouthian, on the same principle that we write Callovian, not Kellawaysian; Bajocian, not Bayeuxian; and Cenomanian, not Lemansian.

PS.—Since the above was written and printed Mr. Lang has proposed the name '*Carixian*' for the lower part of the Charmouthian or Pliensbachian stage, accepting Bonarelli's name of *Domerian* for the upper part, and he derives this name from "the Carixa of Ravennas", which is cited in Roberts' *History of Lyme Regis* as the ancient name of Charmouth (see GEOL. MAG., September, 1913, pp. 401–12).

On this proposal I have several criticisms to offer. In the first place, Mr. Lang remarks that he has "already advocated the propriety of employing the term Charmouthian strictly with its original connotation", and yet he suggests as a new name for a part of this Charmouthian a term taken from what he accepts as the Latin name of the same place. Surely if Carixa was the Roman name for Charmouth it should be used as the basis for the name of the whole Charmouthian stage.

Secondly, the "Chorography of Ravennas" is not a very good authority; its author is really unknown and even the date of it is somewhat uncertain. Moreover, as Mr. Lang himself points out, the name Carixa is probably a latinization of the Celtic words *car-isca*, meaning the River Char, not the place. As a matter of fact, it is very doubtful whether there was any settlement at the mouth of the Char until the time of the wars between the Saxons and Danes.

Thirdly, we seem in danger of being saddled with too many of these latinized names. They are very useful as names for stages, but when it comes to introducing sub-stages with similar names I for one protest. The division of a system into two or more series, of a series into stages, and of a stage into any number of zones seems quite sufficient for practical purposes. The addition of sub-stages merely imposes an unnecessary burden upon the memory.

In England the stages of the Lias have hitherto been called Lower, Middle, and Upper. If it is thought more convenient to divide the series into four or five stages, let us have geographical names for them, but there is no good reason for burdening our nomenclature with a double set of such names.

A. J. JUKES-BROWNE.

TORQUAY.
September 8, 1913.

THE LATE HERBERT KELSALL SLATER.

Sir,—I am informed by Dr. W. F. Smeeth, the principal officer of the Geological Department of Mysore, that a fund is being formed to make some provision for the family of Mr. H. K. Slater of that department, who died recently from the bite of a large Russell's viper while engaged in Geological Survey work in the Shimoga District. An obituary, in which his services to geology are recorded, appeared in this Magazine in July last. He leaves three young children almost entirely unprovided for, and it is urgently necessary to raise a sum sufficient for their upbringing and education.

Contributions may be sent either to Dr. W. F. Smeeth, Bangalore, India, or to me at the address below.

John W. Evans.

Imperial Institute,
London, S.W.

OBITUARY.

SIR GEORGE HOWARD DARWIN,
K.C.B., M.A., LL.D., D.Sc., F.R.S.

Born July 9, 1845. Died December 7, 1912.

In his opening Address to the British Association the President, Sir Oliver Lodge, writes (Birmingham, September 10): "Through the untimely death of Sir George Darwin the world has lost a mathematical astronomer whose work on the tides and allied phenomena is a monument of power and achievement. So recently as August, 1905, on our visit to South Africa, he occupied the Presidential Chair." It was on his return to England after his visit to South Africa that he received the honour of Knight Commander of the Bath from His Majesty.

The second son of the late Charles R. Darwin (author of *The Origin of Species*, etc.), George Darwin was born at Down, Kent, in 1845, and was educated privately by the Rev. Charles Pritchard (later Savilian Professor of Astronomy at Oxford). He entered Trinity College, Cambridge, in 1864, and graduated as a Second Wrangler and Smith's Prizeman in 1868, and in that year he was elected to a Fellowship at Trinity College, which he held 1868–78, and to which he was re-elected in 1884. At first he studied the law, and was called to the Bar in 1874, but returned to Cambridge, where he spent the rest of his life, devoting himself to Solar Mathematics. His *Collected Papers*, which form four volumes, were recently published by the Cambridge University Press. In 1884 he was chosen Plumian Professor of Astronomy in Cambridge.

Sir George Darwin's writings had a most important bearing on Dynamical Geology, especially "On the influence of Geological Changes on the Earth's Axis of Rotation" (Phil. Trans., 1877), "On the bodily Tides of viscous and semi-elastic Spheroids and on the Ocean Tides on a yielding Nucleus" (op. cit., 1879), "On the Precession of a viscous Spheroid and on the Remote History of the Earth" (op. cit., 1879), and "On the Secular Changes in the

Elements of the Orbit of a Satellite revolving about a Tidally Distorted Planet" (op. cit., 1880).

Another of his memoirs may be appropriately recalled, bearing upon the same subject as that recently dealt with by Colonel Burrard (Geol. Mag., September, 1913, pp. 385–8) and the Rev. O. Fisher: "On the Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains" (op. cit., 1882).

In 1877 George Darwin became acquainted with Lord Kelvin, who from that time took a warm interest in all his work and greatly influenced his subsequent researches.

In 1884 he married Maud, daughter of Charles du Puy, of Philadelphia, and leaves two sons and two daughters. His eldest son, Charles, was a scholar of Trinity in 1905, and graduated as Fourth Wrangler in Mathematics in 1909.

Sir George delivered a course of lectures at Boston, U.S., in 1897 under the title of "The Tides", which was subsequently printed as a popular volume entitled *The Tides and Kindred Phenomena of the Solar System* (1898).

He was a Vice-President of the International Geodetic Association, a member of the Meteorological and Solar Physics Committees, Doctor of nine Universities, Foreign Honorary Member of twenty Societies and Academies, and Foreign Correspondent of twelve others. He served as a member of Council of the Royal Society for seven years, and as Vice-President for two years, and was President of the Cambridge Philosophical Society and Vice-President of the Astronomical Society.

Sir George Darwin was also the recipient of the Royal Astronomical Gold Medal in 1892, Royal Medal, Royal Society, in 1884, and the Copley Medal in 1911, and several others.

TEMPEST ANDERSON, M.D., D.Sc., F.G.S.

Born 1846. Died August 26, 1913.

The death is announced from enteric fever whilst on his voyage home from the Philippine Islands of Dr. Tempest Anderson, of York. The son of the late Mr. William C. Anderson, M.R.C.S., a member of an old and well-known Yorkshire family, Dr. Tempest Anderson was born at York in 1846. He was educated at St. Peter's School, York, and had a distinguished student's career at University College, London. He was a well-known scientist. As President of the Yorkshire Philosophical Society he spent a great deal of time and much money in its interests, and it was through his influence that a new lecture hall was recently added to the York Museum. Dr. Anderson's special branch of study was volcanic phenomena, and this subject, illustrated by photographs, he brought on many occasions before the British Association. He was author of *Volcanic Studies in Many Lands*, 1903 (see review by W. H. Hudleston, Geol. Mag., 1903, p. 160). After the terrible eruption in May, 1902, of the Soufrière, in St. Vincent, one of the West India Islands, he and Dr. J. S. Flett were commissioned by the Royal Society to investigate the matter. Their joint report was published in the *Philosophical Transactions* for 1903. Dr. Anderson revisited the West Indies in 1907, and gave an account of the subsequent changes in the volcanic districts of St. Vincent and Martinique, his report being published in 1908. Dr. Anderson was Tyndall lecturer on volcanoes at the Royal Institution. Professionally he was a specialist in diseases of the eye. He took a deep interest in the promotion of open spaces and garden cities. He was an extensive traveller, and there were very few places where volcanic eruptions were known to have occurred that Dr. Anderson had not visited. He was a noted Alpine climber and photographer, and had produced some splendid views of places of interest which he visited during his travels. Among the numerous appointments and distinctions which he held were the following: Consulting ophthalmic surgeon to the York County Hospital; Fellow of University College, London; member of Council and former Vice-President of the British Association; President of the Museums Association, 1910; and member of the Council of the Geological and Royal Geographical Societies. Dr. Tempest Anderson was one of the five original Trustees[1] of the 'Sladen Fund' established by his sister, Mrs. Walter Percy Sladen, F.L.S., for the advancement of scientific research in Anthropology, Zoology, Botany, and Geology. Dr. Anderson was unmarried.[2]

WILLIAM HENRY SUTCLIFFE, F.G.S.

BORN SEPTEMBER 25, 1855. DIED AUGUST 18, 1913.

W. H. SUTCLIFFE was born at Ashton-under-Lyne, educated at Manchester Grammar School and Owens College (now Manchester University). Trained for the cotton trade, he was for some time manager of a cotton-mill near Rouen. In 1885 he became manager for Messrs. E. Clegg & Sons' cotton-mills at Shore, Littleborough, near Rochdale, Lancashire, and subsequently became one of the managing directors. The firm is one of the largest cotton manufacturers in the district and employs about 1,500 workpeople.

Apart from his business Mr. Sutcliffe was best known as a geologist and archæologist and a member of many scientific societies. He early took an interest in the remains of primitive man found on the hills in the neighbourhood of Rochdale, and the fruits of his labours and that of other workers are to be seen in the fine collection of flint implements and other remains in the cases of the museums at Rochdale and Manchester University.

One of his most interesting contributions was a joint paper with Mr. W. A. Parker, F.G.S., on "Pigmy Flints, their provenance and use", in which they almost conclusively proved that the use of these minute flints was as skin-scrapers. He also communicated a paper to the Manchester Literary and Philosophical Society on March 18 last, on "A Criticism of some Modern Tendencies in Prehistoric Anthropology". This was an admirable study of recent theories as

[1] Dr. Tempest Anderson, F.L.S., F.G.S.; Henry Bury, M.A., F.L.S., etc.; Professor Herdman, F.R.S.; T. Bailey Saunders, M.A.; and Dr. Henry Woodward, F.R.S.

[2] For many of the above particulars we are indebted to the *Morning Post*, August 29, 1913.

to the antiquity of man, and was a careful weighing and sifting of the evidence in connexion with some of the discoveries of recent years. He strongly attacked the theory that the so-called 'Eoliths' were the work of man, and also the idea that the Galley Hill skeleton found some years ago in Kent and the one found near Ipswich were of very early type, and for this object he visited Ightham, Kent, and the locality where the Ipswich skeleton was found.

As a geologist he has been the means of considerably extending our knowledge of the palæobotany of the Lower Coal-measures; and the 'Bullion Mine', Shore, near his residence, has become widely known on account of the rich harvest it has yielded of specimens new to science, and his name has been commemorated in *Tubicaulis Sutcliffei* and in *Sutcliffia insignis*.

He has also been associated with other well-known local geologists in the discovery of the very rich fauna in the Middle Coal-measures at Sparth, Rochdale, about which Dr. H. Woodward gave a paper at the British Association Meeting at York in 1906, when he named a new species of fossil arachnid, *Geralinura Sutcliffei*, and this specimen with many others have been presented by Mr. Sutcliffe to the Geological Department of the British Museum (Natural History).

Most of his holidays in recent years have been devoted to geological investigation, and he invariably returned with many valuable specimens, some of which have enriched the Rochdale and Manchester Museums. One of his recent finds was a fine specimen, 20 feet long, named *Plesiosaurus homospondylus*, from the Lias of Saltwick Bay, near Whitby, which is preserved in the Manchester Museum.

In one of his archæological investigations he endeavoured to trace the Roman Road over Blackstone Edge (Pennine Range) north-east of Rochdale, and had a large portion of ground uncovered beneath the turf and heather so as to trace its course for a considerable distance.

Mr. Sutcliffe was elected a Fellow of the Geological Society in 1903, and contributed a joint paper to that Society in 1904 on *Eoscorpius sparthensis*, sp. nov. (Quart. Journ. Geol. Soc., vol. lx, p. 394).

He was a member of the Manchester Geological Society and University Geologists' Association, the Manchester Literary and Philosophical Society, and many other bodies. He was also a member of Council of the Manchester Museum.

He joined the Rochdale Literary and Scientific Society in 1886, became a member of Council in 1898, and was last year elected President, when he gave a very interesting address on "The Evolution of Tools", to illustrate which he had on exhibition about 500 specimens, showing the development of the principal form of tools demonstrating the evolution of the textile industry.

He had a large circle of English and foreign friends amongst men of science, including the Editor of this Magazine. Mr. Sutcliffe was in private life and in his scientific pursuits one of the kindliest and most genial of men.

For some months he had been in failing health, and died at Weymouth on August 18 last, to the deep regret of his many friends. He leaves a wife, one son, and two daughters to mourn his loss.

S. S. P., W. A. P.

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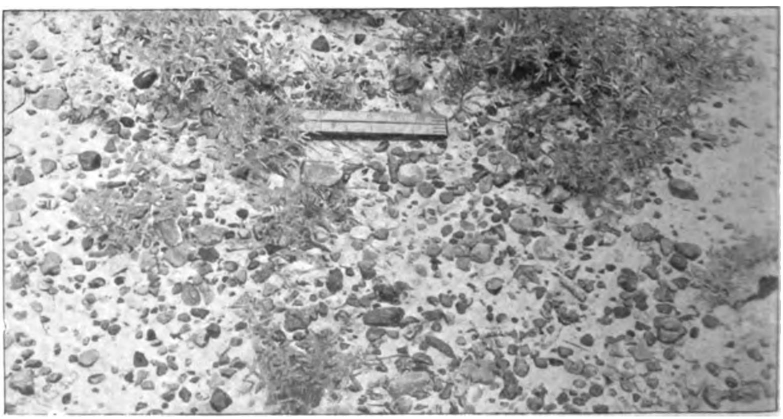

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T. O. Bosworth photo.

Vegetation and arid Surface-features in South-West Texas.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. XI.—NOVEMBER, 1913.

ORIGINAL ARTICLES.

I.—Notes on the Semi-Arid Conditions in a Part of Southern Texas.

By T. O. Bosworth, D.Sc., B.A., F.G.S.

(PLATES XVI AND XVII.)

Introduction.—The conditions described below were observed over a large part of South-West Texas; but the local details apply to an area of one or two hundred square miles in McMullen County, geologically surveyed by the writer in 1912. The centre of observations was a little mining ranch named Crowther, about 50 miles south of San Antonio and 80 miles from the Gulf of Mexico, near the inland limit of the Gulf coastal plain. The country for many miles around Crowther is practically untouched by man, though a somewhat primitive little local railroad now under reconstruction reaches to within 16 miles of it.

Geological Structure of the Region.—The coastal plain is, say, about 100 miles wide, extending along the coasts of Louisiana, Texas, and Mexico. The strata are very slightly inclined towards the sea and strike approximately parallel with the coast. Apparently there has been a gradual recession of the sea, accompanied by a slight uptilting of the land, so that the Quaternary and latest Tertiary were not deposited far inland. Near the coast the plain is nearly flat and almost at sea-level. Inland the ground rises, imperceptibly at first, and then by successive gentle steps. Towards the inland limits of the plain there has been considerable denudation, and the rocks are well exposed. Continuing through this more rocky country, at length we reach the block-faulted Cretaceous beds beyond the plain. In the area considered, the United States Government has not yet carried out either its geological or topographical survey, but bulletins and maps have been published dealing with one or two other portions of the plain.[1]

Climatic Conditions.—From east to west along the coastal plain, there is a gradual change in climate, the Louisiana and South-East Texas end being moist, whilst the South-West Texas end is dry. The rainfall in McMullen County is about 22 inches, and most of it falls

[1] C. W. Hayes & W. Kennedy, "Oil Fields of Texas-Louisiana Gulf Coastal Plain": Bulletin B 212, United States Geological Survey.

quickly within a few weeks of the spring. The mean temperature exceeds 80° F. throughout the three summer months, but it is not much above 50° F. in January. The air is very clear, and mirages are visible in summer and autumn. The wind blows almost constantly in from the Gulf, and often is very strong, causing sand-storms. At times there is a sudden fall in temperature brought about by a cold wind from the North, known as a 'Norther', which occasionally attains to the violence of a mild hurricane.

Geology and Topography around Crowther.—Around Crowther the high ground (about 700 feet above sea-level) is a steep dissected escarpment or plateau, with bluffs sometimes nearly 100 feet high and outliers in the form of table-like hills. The high ground is capped by a series of nearly horizontal calcareous sandstones, shales, and clays, about 50 feet thick, containing marine fossils. Below is a thick series of soft sands and clays containing much fossil wood and a few freshwater shells. The lower ground viewed from afar off appears flat, but is found to be an irregular succession of different levels with small steep steps between them. The whole is intersected by innumerable steep narrow gullies. A few miles away to the south lies the wide River Frio, an intermittent stream whose waters join the River Nueces, which flows into the Gulf.

Fauna.—A few years ago wild cattle and horses roamed these plains, probably obtaining a bare living during the spring months and retreating elsewhere in the drier seasons. Amongst the present fauna are some deer, the coyote, hares and rabbits, rattlesnakes, the 'horned toad', birds, etc. Until quite recently a tribe of wandering Indians held sway, and their old camping-grounds are marked by numerous stone arrow-heads and other remains. There is a wide territory hardly touched as yet by man, except at a few places where Artesian water has been won to irrigate the land.

Vegetation.—The country is devoid of grass, but is more or less liberally sprinkled over with the prickly-pear cactus and stunted bushes of 'mezquit' and chaparal. All these plants are well protected with thorns and spines to resist any wretched animals which strive for existence on this barren land. In winter, cattle overcome with hunger and thirst will eat the prickly but juicy cactus leaves until their tongues are so bristling with long thorns that they are unable to draw them back into their mouths. Men who have kept cattle in these places go around the cactus bushes with gasoline lamps, burning off the thorns. The mezquit, besides being armed with thorns, has an exceedingly bitter taste, but the beans which grow upon this bush are the most serviceable fodder which the land provides. Notably amongst the other peculiar prickly desert plants is the large aloe, known as the 'Spanish dagger'. At the centre of this plant reaching often to a height of 10 or 12 feet is a straight flower-stem bearing a spire of thickly clustered flowers which the animals find edible. The flower is amply defended by a chevrise of long strong leaves of sword-like shape, with sharp points (see Pl. XVI, Fig. 1). Along some of the watercourses, however, are a few live oaks and other trees. Large trees grow profusely on the alluvial soil alongside the River Frio.

Denudation and Transportation.—Despite the scantiness of rainfall this is a region of conspicuously rapid denudation; and the transportation of the detritus to the sea is ever visibly in operation.

The Sun's Heat.—The sun's rays and changes of temperature, as usual in deserts, are causing cracking and crumbling on all bare surfaces, so that debris is continually falling down the sides of every scarp and gully. A curious instance was observed where the sun's heat had had a hardening effect. Here in the freshwater series are certain white clays (comparable with fire-clays) which are very dry and porous, and which can readily absorb much water and become plastic. In places the occasional rain has washed them, leaving smooth hummocks, and the heat of the sun has then baked these almost as hard as pot, so that they ring when struck with the hammer.

The Wind.—The wind is usually blowing steadily from the Gulf, and there is a constant visible drifting of material to northward into the valleys of the River Frio and its branches. So effective is the wind that in most cases the talus is disintegrated and removed from the foot of the hills as fast as it can form, and consequently the bluffs are but little protected, and steep scarps are the rule.

Pebbles.—The fragments of sandstone, calcareous sandstone, and claystone seldom survive even as small pebbles at any distance away from the cliffs, but are quickly reduced to their component grains. Nevertheless, the desert surface generally is littered over liberally with certain small pebbles which decrease in size at a distance from the bluffs, until in the flat plains they are about the size of beans. In places they are some inches apart, in others they almost conceal the sand (Pl. XVI, Fig. 2). These pebbles in this district are a peculiar assortment, for they consist almost all of chert, agate, chalcedony, and opal. The pebbles are cut so as to have many facets and many sharp edges and corners, and are highly irregular in shape: indeed, they resemble broken flints. None were found of the typical dreikanter pattern, though all are most highly polished and almost lustrous (Pl. XVI, Fig. 3). Approaching the bluffs they are larger and have less facets, and some can be found whose undersides are fractured surfaces which have not yet been presented to the wind. The source of this chalcedonic material is the marine series which caps the bluffs. In those rocks there are numerous fossils, most of which (corals, gasteropods, etc.) are preserved beautifully in semi-opalescent silica, many cracks in the rocks also being occupied by this material. The wide-spread pebbles probably indicate the former extension of the series over many miles, and are evidence of the considerable denudation effected under present conditions. Frequent also among the pebbles are larger stones consisting of silicified wood derived from the freshwater series. Some of the grey calcareous sandstones which form pebbles at the foot of the cliffs are somewhat curiously affected. Outside they have a white shell-like coating up to $\frac{1}{4}$in. thick (which is soluble in hydrochloric acid), and underneath this is a reddish coating of iron oxide. These materials presumably have been drawn out to the surface of the stone by capillary action when heated by the sun after moisture has sunk into them.

The Sand and Soil.—The desert sand is derived from the rocks at hand; it is rather fine and not particularly rounded. It may be a few feet deep, but more often it is only a few inches, and even in the low flat ground bare rocks are here and there exposed. Occasionally sand completely covers a layer of pebbles, but generally it seems to be the presence of pebbles which enables the sand to remain at rest; vegetation may then obtain a footing and allow the accumulation of further sand. Where vegetation retains a hold, patches of rich dark soil are readily formed which is sometimes 3 or 4 feet thick. But owing to the wind (and also to the water-flows) the distribution of sand and soil is ever undergoing rapid change. At the ranch mentioned, for instance, an attempt was being made to grow a plot of maize; at one end of the plot a man was ploughing, but at the other end the ground ploughed the day before was so completely covered by sand that no marks of the plough were visible. Again, during the rains, the bare rocks became exposed in places where two days before there had been 3 feet of soil.

Work of Water.—The land surface is intersected by innumerable watercourses (Pl. XVII, Fig. 4) which lead ultimately northward and westward into the River Frio or its tributary, the San Miguel River. During the greater part of the year those rivers are dry, though a little water can usually be obtained by digging in the river-bed. At other times there is a moderate flow of water wandering about in a wide valley which is choked up with a great amount of sand and stones, often disposed in big shoals. These rivers are always overloaded, and at the time of the rains they become torrents bearing an immense load to the sea. The gullies leading into them are narrow gorges up to, say, 30 feet deep, with steep sides, often vertical. By their complicated windings and the windings of their countless little tributaries where they converge they dissect the ground into 'bad lands' on a small scale (Pl. XVII, Fig. 5). Further from the river the creeks become much smaller, so that the area is mainly cut up by a network of narrow little dry gullies a few feet deep. It was the writer's good fortune to be present in April when the rains came. The creeks filled immediately, and overflowed so that sheets of water spread far and wide, flowing out over the sand and forming large 'water spreads'. Fresh watercourses were cut from day to day, so that the system was completely changed. Talus was washed away from the bluffs, pebbles were spread out or washed up into banks, new shoals of sand were formed, stunted trees were uprooted, and soil removed. At intervals between the rain-storms, which usually occurred at night, the sun shone brightly, the waters partly dried up and revealed in the creeks and on the flats fresh sand and mud surfaces all marked with water-ripples and sun-cracks, where previously had been wind-ripples or dry sand.

Ripples.—These water-ripples, whether in the creeks or on the flat, when formed by advancing water present one constant pattern, generally in high relief—a kind of horseshoe pattern with all the 'shoes' leading forward (Pl. XVII, Fig. 6). At bends in the


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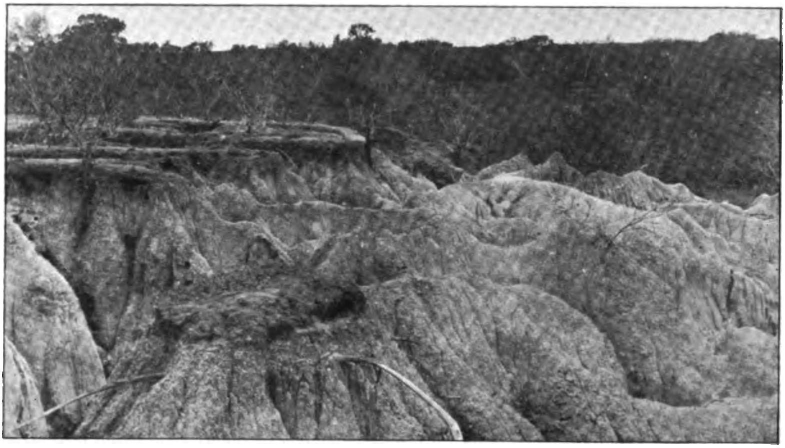
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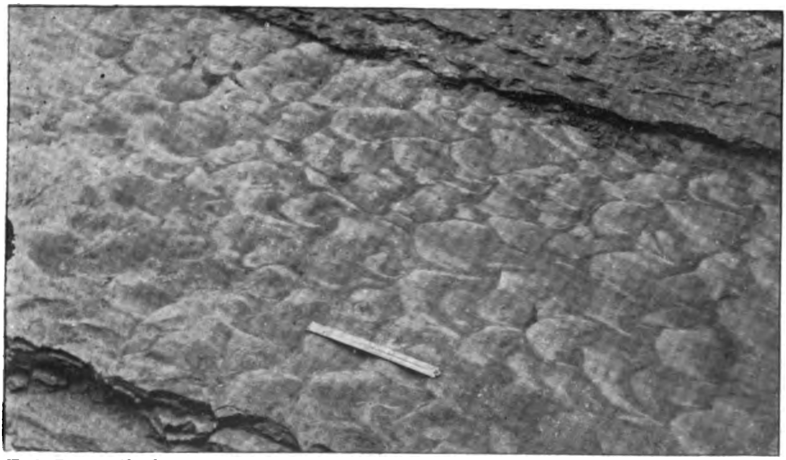
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T. O. Bosworth photo.

Arid Surface-features in South-West Texas.

course of the current the 'horseshoes' are obliquely distorted.[1] The wetted surfaces, having the appearance of mud flats, are rapidly cracked up by the sun's heat into hexagonal patterns with wide cracks. Drying proceeds rapidly and sometimes surface films of the hexagons may be seen curling up, each into a thin roll, and then crumbling up into ordinary fine quartz sand. Remarkably rapid was the effect of the sudden rains upon the vegetation. The stunted mezquit bushes put forth abundant light yellow-green leaves, and in a day or two the ground was ablaze with bright-coloured flowers, so that in every direction as far as the eye could see the earth appeared red or blue or yellow, or of varied hue, as the case might be. (These small plants display much flower and very little leaf.) A multitude of small Gasteropods feed upon this vegetation.

Gypsum.—Gypsum is being formed almost everywhere. In the floors of the gullies are occasional growths, several feet across, composed of spherulitic structures, the spherules being upwards of several inches in diameter and built of radiating fibres. On all talus slopes where there is argillaceous material, thin sheets and slabs of gypsum are ever forming. They appear to grow a few inches beneath the surface, and also in cracks. The slabs are formed of fibres normal to the plane, and are usually only a fraction of an inch in thickness, though some are thicker. There are also single larger crystals of selenite of the usual form. It appears that gypsum grows very readily in argillaceous matter which is much exposed to the sun's heat and is occasionally moistened.

Desert Deposits.—Although the whole region is overspread with sand, yet nowhere were any thick deposits observed to be forming. Indeed, the resultant effect of wind and water in this area is gradual denudation, with intermittent sudden transferences of material to the River Frio, and thence by sudden impulses to the sea. The deposit due to the denudation in this desert is a delta cone in the Gulf of Mexico, and it is only there that the blown sand and the multitude of hard wind-cut stones come to a lasting rest.

EXPLANATION OF PLATES XVI AND XVII.

FIGS.

Plate XVI.

1. Characteristic vegetation of the arid regions of Texas, consisting of: 'prickly-pear cactus' (*Opuntia vulgaris*), 'Spanish dagger,' the large aloe (*Yucca aloifolia*), bushes of 'mezquit' (*Prosopis glandulosa*), and 'chaparal' (thick bramble-bushes entangled with thorny shrubs in clumps).
2. Sand and stone-covered plains (typical view).
3. Wind-cut pebbles on the desert (mainly chalcedony).

Plate XVII.

4. A dry watercourse.
5. Tributary entering the River Frio valley (the foreground is one bank of the tributary). In the background is the Frio valley.
6. After the rains. The surface shows the form of the ripples left by a water-flow; all of horseshoe pattern, with the 'footmarks' pointing forward.

[1] Rarely (as in some places where steady flows lapped a sandbank) a more linear type of ripple was seen on sloping surfaces. Also linear forked ripples were formed occasionally in still pools where the water was agitated by wind.

II.—The Twelfth International Geological Congress in Canada.

By B. Hobson, M.Sc., F.G.S.

AT the Stockholm meeting of the Congress in 1910 an invitation to hold the twelfth meeting in Canada was accepted. As the Congress met in the United States in 1891 and in Mexico in 1906, members were thus afforded an opportunity of visiting all the great divisions of North America. The Canadian meeting was held at Toronto from August 7 to 14, 1913, under the presidency of Professor F. D. Adams, of McGill University. About 600 members attended it, although the total enrolled was nearly twice as great, and 46 countries were represented among the members. The Congress was formally opened by the Right Hon. Sir Charles Fitzpatrick, on behalf of H.R.H. the Duke of Connaught, the Honorary President, who was unavoidably absent, and speeches of welcome were made by others. Dr. R. W. Brock, Director of the Geological Survey of Canada and General Secretary of the Congress, presented to the Congress a monograph entitled "The Coal Resources of the World", the result of an inquiry made upon the initiative of the Executive Committee of the Twelfth Congress, with the assistance of Geological Surveys and mining geologists of different countries. It consists of three quarto volumes of about 400 pages each (11 by 8½ inches) and an atlas of 66 pages of maps in colours (13½ by 19½ inches) published by Morang & Co., of Toronto, at $25 per set, net. It forms a fitting companion to the volume on the Iron Ore Resources of the World, published under the auspices of the Stockholm Congress.

In the second circular of invitation to the Toronto Congress seven topics were mentioned as having been selected by the Executive Committee as the principal subjects of discussion. The first of these was "The Coal Resources of the World". Not much was said on this subject, no doubt owing to those best qualified to speak having given their views in the monograph. The second subject was "Differentiation in Igneous Magmas". On this subject Professor R. A. Daly read a paper entitled "Sills and Laccoliths illustrating Petrogenesis". He advocated gravitative differentiation and tabulated seventy different sills and laccoliths, in twenty-nine of which he maintained that such differentiation is shown. He also maintained that many species of igneous rocks are due to large-scale assimilation of country rocks by overhead or other stoping, giving rise to syntectic magmas. Dr. A. Harker followed with a paper on "Fractional Crystallization the Prime Factor in the Differentiation of Rock Magmas", in which he pointed out that a rock magma at a temperature below that of the upper part of the temperature range of crystallization must be pictured as an open fabric or sponge of crystalline matter with interstices occupied by liquid magma. Under crustal stresses the interstitial liquid may be squeezed out and thus differentiation may arise, as the crystalline and liquid parts necessarily differ in composition. A stratification and differentiation may also be brought about by gravity acting upon a wholly fluid magma or (more effectively) by the sinking of crystals in a magma still mainly fluid.

Dr. Iddings in a paper on "Some examples of Magmatic Differentiation and their bearing on the problem of Petrographical Provinces" agreed with Dr. H. S. Washington in emphasizing the importance of sufficient analyses. In Dr. Washington's paper on "The Volcanic Cycles in Sardinia" he pointed out that there are three cycles—firstly, that of the extensive early (Tertiary) flows; secondly, that of the two large volcanoes of Monte Arci and Monte Ferru; thirdly, that of the small recent scoria cones. In the first two cycles the sequence began with acid, followed by intermediate and basic rocks. The lavas of the third cycle are felspar basalt in which no definite sequence has as yet been made out. Rocks of typically Atlantic and others of typically Pacific type occur in Sardinia, even in the same volcano, as at Ferru and Arci. Professor W. H. Hobbs in a paper on "Variations in Composition of Pelitic Sediments in relation to Magmatic Differentiation" endeavoured to account for some of the variations in igneous rocks usually attributed to differentiation by supposing many igneous rocks to be the result of the fusion of argillaceous sediments. Dr. V. Sabatini gave "A Classification of the Eruptive Rocks of Italy". The discussion was continued by Dr. J. W. Evans, Professor F. Loewinson-Lessing, Professor A. Bergeat, Dr. W. Cross, and summed up by Professor H. Bäckström, who advocated reserving judgment until more experimental work has been done.

The third subject discussed was the "Influence of Depth on the Character of Metalliferous Deposits". Professor J. F. Kemp opened the discussion with a paper bearing that title. He concluded that (1) while there seems to be nothing to prevent precipitation at greater depths than we have yet reached, yet conditions seem to be specially favourable in those portions which lie between the present surface and 2,000–4,000 feet in depth; (2) secondary enrichment has increased the yield of those portions of many veins which are above 1,000 feet in depth, the vertical extent of its action being limited to a relatively short stretch below the ground-water level. Professor J. P. Krusch followed with a paper on the colloidal precipitation of primary and secondary ores. Professor W. H. Emmons in "The Mineral Composition of Primary Ore as a factor determining the Vertical Range of Metals deposited by Secondary Processes" outlined the processes of enrichment of sulphide ores of gold, silver, and copper, and reviewed some of the more important experiments that may illustrate this process. Dr. L. L. Fermor "On the Formation in Depth of Oxidized Ores and of Secondary Limestones" stated and illustrated the thesis that when deposits consisting of chemical sediments, such as oxides and carbonates as of iron, manganese, or calcium, admixed with mechanical sediments, such as sand and clay, are buried to a depth sufficient to bring them into the zone of anamorphism, reactions take place, which frequently necessitate the elimination from the oxides of oxygen in excess of protoxide proportions, as from Fe_2O_3 and MnO_2; of carbon dioxide from carbonates; and of water from hydrated oxides, such as limonite. It seems to be usually tacitly assumed that these escape or are removed from the scene of action, but it is conceivable that the pressure is such that they are unable to escape. When, in course of time, this pressure is released these substances will probably effect a reversal of the original change. P. F. Fanning gave "A contribution to the Metallogeny of the Philippine Islands", and Dr. M. Maclaren a paper on "The Persistence of Ore in Depth".

The fourth topic discussed was "The Origin and Extent of the Pre-Cambrian Sedimentaries". Dr. J. J. Sederholm in "Different Types of Pre-Cambrian Unconformities" described the conditions in Fenno-Scandia, and incidentally mentioned that "it seems that our separation of the strongly metamorphic schists, near Lake Ladoga, from the Kalevian proper, as a much older subdivision, designated Ladogian, was founded on an erroneous correlation between the post-Kalevian granites at Lake Ladoga and the younger pre-Kalevian granites of Western Finland". In a second paper "On Regional Granitization (or Anatexis)" Sederholm described palingenesis or the formation of new rocks in Finland by the refusion *in situ* of pre-existing igneous or sedimentary rocks. Professor G. A. J. Cole gave "Illustrations of the Formation of Composite Gneisses and Amphibolites in North-West Ireland". Professor W. S. Bayley described "The Pre-Cambrian Sedimentary Rocks in the Highlands of New Jersey". Dr. G. F. Matthew dealt with "Cambrian and Pre-Cambrian in the Maritime Provinces of Canada".

The fifth subject discussed was "The Subdivisions, Correlation, and Terminology of the Pre-Cambrian". Dr. A. Strahan gave an account of "The Subdivisions and Correlation of the Pre-Cambrian Rocks of the British Isles", and stated that we seem to lack justification for attempting a chronological sequence of pre-Cambrian rocks in the British Isles, further than is involved in placing the Lewisian gneiss among the oldest, and the Torridonian among the later formations. Dr. J. Horne described the pre-Cambrian and Dalradian rocks of Scotland. Professor A. C. Lawson read a paper on "A Standard Scale for the Pre-Cambrian Rocks of North America", in which he took the Lake Superior region as typical, and tabulated in ascending order Coutchiching, Kewatin (grouped together as Ontarian), Laurentian granite gneiss, batholithic in Ontarian, *Unconformity*, Lower Huronian, *Unconformity*, Upper Huronian, Algoman granite gneiss, batholithic in Huronian, *Eparchæan Interval*, Animikie, *Unconformity*, Keweenawan (Nipigon), grouped together as Algonkian, *Unconformity*, Upper Cambrian (Potsdam). Mr. W. H. Collins, of the Geological Survey of Canada, in "A Classification of the Pre-Cambrian Formations in the region east of Lake Superior", announced that the gap of 70 miles between the Sudbury and the Cobalt districts has been investigated by the Geological Survey and was closed last autumn so that the sequences in the two areas can be correlated, and he gave a table of correlation. Professor A. P. Coleman read a paper on "The Sudbury Series and its bearing on Pre-Cambrian Classification". The impression made upon the writer by the discussion on American pre-Cambrian classification was that hardly two authorities agree, and that the grouping under the name of Huronian of three or more systems, separated by great unconformities, only leads to confusion. Mr. E. Vredenburg and Sir T. H.

Holland gave separate papers on the classification of the pre-Cambrian in India, and Dr. J. J. Sederholm read "Some Proposals concerning the Nomenclature of the Pre-Cambrian, etc.", the most important of which led to a resolution passed by the Congress that countries which possess contiguous areas of pre-Cambrian rocks should form international committees, including representatives of their Geological Surveys, for the purpose of correlating their pre-Cambrian formations.

The sixth topic of discussion was "To what extent was the Ice Age broken by Interglacial Periods?" Mr. G. W. Lamplugh opened the discussion with a paper on "The Interglacial Problem in the British Isles". [This subject was dealt with in detail in his address to the Geological Section of the British Association at York in 1906.] He now stated that his views "have not been modified since in any essential particular", nor could he see any "reason for supposing that our Islands had been more than once enwrapped by ice-sheets, however the case may stand in other countries"; and is of opinion "that the great ice-sheets held their ground in the basins surrounding our Islands throughout the deposition of the drift series, and that the supposed Interglacial deposits are indicative only of marginal fluctuations and of the independent culmination of separate lobes during the long period of glaciation".

Professor A. P. Coleman gave "An Estimate of Post-Glacial and Interglacial Time in North America"; Mr. N. O. Holst gave (in French) "The Beginning and End of the Glacial Period"; Dr. Warren Upham, "The Sangamon Interglacial Stage in Minnesota and Westward." Professor T. F. W. Wolff, "On Glacial and Interglacial in North Germany," stated that there were three glaciations in that region, and that at Phöben near Potsdam in one and the same bore-hole two stratigraphically and faunistically distinct interglacial horizons occur, the lower with ***Paludina diluviana*** and the upper with ***P. Duboisii***.

The seventh topic for discussion was "The Physical and Faunal Characteristics of the Palæozoic Seas, with reference to the value of the Recurrence of Seas in establishing Geological Systems". Professor T. C. Chamberlin contributed "The Shelf Seas of the Palæozoic and their relations to Diastrophism and Geological Systems". Professor G. Steinmann followed with "The Palæozoic Seas in South America". Professor C. Schuchert read a paper on "The Delimitation of the Geologic Periods illustrated by the Palæogeography of North America". He has drawn up eighty-five maps of North American geographics since the Cambric. He proposes to divide geologic time into periods based on the amount of submergence as measured by the area submerged as shown on these maps. The Cambrian is divided into Waucobic, Acadic, Ozarkic; the Ordovician into Canadic, Ordovicic, Cincinnatic; the Mississippian into Mississippic, Tenneseic; while the Pennsylvanic and Permic are united in a single system. Dr. E. O. Ulrich discussed "The Ordovician–Silurian Boundary", and incidentally rejected Schuchert's Cincinnatic System. Professor F. Frech described "The Palæozoics of the Bagdad Railway". Dr. O. Holtedahl in his paper "On the Old Red

Sandstone Series of North-Western Spitzbergen" gave the following correlation :—

Spitsbergen.	*Thickness.*	*Scotland.*
Wijde Bay Series .	2,000 metres . .	Upper Old Red.
Grey Hoek Series .	2,000 ,, . .	Middle Old Red (Orcadian).
Wood Bay Series .	2,500 ,, . .	Lower Old Red (Caledonian).
Red Bay Series . .	2,300 ,, . .	Downtonian.

For want of guide fossils in the Grey Hoek Series its contemporaneity with the Middle Old Red is not proved. A paper on Periodicity of Palæozoic orogenic movements by T. C. Chamberlin and R. T. Chamberlin was also read. Six papers on tectonics and many miscellaneous papers were contributed, among which two papers on the geology of Argentina, by H. Keidel and Bailey Willis respectively, deserve special mention.

No account of the meeting of the Geological Congress in Canada would be complete without a reference to the excursions, which were to many the most attractive feature. Twelve excursions were arranged to take place before the meeting. The chief of these were that to Quebec and the Maritime Provinces, led by G. A. Young, J. M. Clarke, E. R. Faribault, etc., occupying nineteen days; that to Haliburton–Bancroft (Ontario), conducted by F. D. Adams and A. E. Barlow, seven days; and that to Sudbury–Cobalt–Porcupine (Ontario), led by W. G. Miller, ten days. Ten short excursions took place during the meeting and nine excursions after the meeting. The chief of these were the two great transcontinental excursions, C 1, by the Canadian Pacific main line over the Kicking Horse Pass to Victoria, Vancouver Island, and back, twenty-three days, and C 2, by the Crow's Nest Pass to the same place and back, twenty-three days, and last, but not least, C 8, to Yukon and Malaspina and back, twenty-five days. The excursions were splendidly organized, and in connexion with them guidebooks, in ten sections, divided into thirteen handbooks, were prepared. These comprised a total of 2,012 pages, illustrated by 154 maps, mostly coloured, 41 sections or drawings, and 281 process reproductions of photographs. They not only summarize pre-existing knowledge, but contain much new material.

If in this short account little has been said of the public functions, such as the conferring of honorary degrees and the unveiling at Percé and at Ottawa of memorial tablets to Sir William Logan, strict limitations of space must be the writer's excuse.

III.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[1]

(*Continued from the October Number, p. 446.*)

It is now time to turn to the consideration of the part played by these organisms in the formation of sedimentary rocks through the successive geological periods.

[1] Edited and slightly abridged with the author's permission from the original Address as delivered at Birmingham, before Section C at the British Association meeting.

Archæan.

In the Archæan rocks no undoubted remains of Calcareous Algæ have yet, so far as I am aware, been recorded, but Sederholm considers that certain small nodules in the Archæan schists of Finland may represent vegetable remains. I may also perhaps here refer to some curious oolitic structures which I met with in Spitzbergen in 1896 when examining the rocks of Hornsund Bay. These oolites occur on the south side of the bay, and are closely connected with massive siliceous rocks which may represent old quartzites. The whole series is much altered, and detailed structure cannot now be made out. The rocks occur apparently stratigraphically below the massif of the Hornsund Tinde, and may belong either to the Archæan or the base of the Heckla Hook Series. As, however, similar rocks have not been recorded from the type district of Heckla Hook, they may be referred provisionally to the Algonkian, and may represent the quartzites and earthy limestone of the Jotnian Series of Scandinavia. They are mentioned here in connexion with Mr. Wethered's view that oolites are essentially associated with the growth of *Girvanella*.

Cambrian.

Passing on to the Palæozoic rocks, we find in the Cambrian deposits but few indications that Calcareous Algæ played any considerable part in their formation.

This is no doubt due, to some extent, to the conditions under which these deposits accumulated in the classical localities where true calcareous deposits are typically absent. In the Durness Limestone, however, where considerable masses of dolomites occur, the conditions would appear at first sight to have been more suitable for the growth of these organisms; but even here the slow rate of accumulation and the large amount of contemporaneous solution may have militated against their preservation. At the same time, it is possible that a systematic search in the calcareous facies of the Cambrian rocks in the North of Europe and America may result in the discovery of the remains of some members of this group. That there is ground for this suggestion is shown by recent work in the Antarctic Continent.

Professor Edgeworth David and Mr. R. E. Priestley have discovered among the rocks on the north-west side of the Beardmore Glacier dark-grey and pinkish-grey limestone containing the remains of Archæocyathinæ, Trilobites, and sponge spicules, together with abundant remains of a small calcareous alga referred provisionally to *Solenopora*. From the photographs exhibited by Professor David on the occasion of his lecture (February 8, 1911) to the Geological Society, I have little doubt that this reference is correct.

A further occurrence of *Solenopora* is also reported from fragments of a limestone breccia collected by the Southern party from the western lateral moraine of the same glacier. Speaking of the fauna discovered in this limestone Professor David remarks: "The whole assemblage is so closely analogous with that found in the Lower Cambrian of South Australia as to leave no doubt as to the geological age of the limestones from which these fragments are derived."[1] This discovery,

[1] Eleventh Internat. Geol. Congress Report, 1910, p. 775.

therefore, extends the vertical range of this widely distributed genus down to the oldest Palæozoic rocks. It is interesting to note that the rocks in which the *Solenopora* occurs on the Antarctic Continent contain a development of pisolite and oolite, and that this is also the case in the Australian equivalents. In 1887 and again in 1891 Bornemann described and figured species of *Siphonema* and *Confervites*[1] from the *Archæocyathus* limestones of Sardinia. As regards the former genus, it was shown by Dr. Hinde[2] to be congeneric with *Girvanella* (Nich. & Eth.). It is of interest, however, to note that Bornemann describes this form as a calcareous alga, and compares it with existing subaerial Algæ growing on the surface of limestone rocks in Switzerland. The latter genus is stated by Seward to be possibly "a Cambrian alga, but the figures and descriptions do not afford by any means convincing evidence" (*Fossil Plants*, vol. i, p. 178).

More recently, in 1904, Dr. T. Lorenz[3] has described remains of *Siphoneæ* from the Cambrian rocks of Tschang-duang in Northern China, for which he erects two new genera, *Ascosoma* and *Mitscherlichia*, placing them in a new family, the Ascosomaceæ. These Algæ build important beds of limestone, the individuals often attaining a length of 4 cm. and a thickness of 1·5 cm. In 1907 Bailey Willis[4] reported *Girvanella* associated with oolites in the lowest Cambrian Man-t'o Beds in China. It is probable, therefore, that as our knowledge of these rocks is extended, Calcareous Algæ will be found to play an important part in the Cambrian limestones of the Asiatic Continent and Australia.[5]

Ordovician.

In the Ordovician rocks the remains of Calcareous Algæ become much more abundant; they are very widely distributed and for the first time they become important rock-builders. In Britain the chief genera met with are *Girvanella* and *Solenopora*. These two organisms occur abundantly in the Scottish Ordovician rocks of the Girvan area, where they appear to have contributed largely to the limestones of the Barr Series in Llandeilo–Caradoc times.

As already mentioned, *Girvanella problematica* was originally described by the late Professor Nicholson and Mr. R. Etheridge, jun., from the Craighead Limestone at Tramitchell, where it occurs in great numbers. The officers of the Geological Survey also report it from the Stinchar Limestone of Benan Hill.[6] It occurs in the form of small rounded or irregular nodules, varying in diameter from less than a millimetre to more than a centimetre, many of the nodules showing marked concentric structure. In Benan Burn, where these beds are admirably exposed, the *Girvanella* nodules appear conspicuously on the weathered surfaces, being so abundant as to constitute thick layers of limestone.

[1] Nova Acta Cæs. Leop. Car., 1887 and 1891.
[2] Hinde, Geol. Mag., Dec. III, Vol. IV, p. 226, 1887.
[3] Centralb. f. Min., 1904, p. 193.
[4] *Research in China*, 1907.
[5] Chapman, Proc. Roy. Soc. Vict., 1911, p. 308.
[6] *The Silurian Rocks of Britain*, vol. i, Scotland (Mem. Geol. Surv. U.K.), pp. 487, 494, 496, 500.

Solenopora compacta, var. *Peachii*, which likewise forms important masses of limestone, is found, like *Girvanella problematica*, most abundantly in the Girvan area, but at a somewhat lower horizon, namely, in the 'nodular limestone' and shales forming the lower subdivision of the Stinchar Limestone. The horizon of the Stinchar Limestone is correlated by Professor Lapworth with the Craighead Limestone, and considered to represent the summit of the Llandeilo or the base of the Caradoc rocks of the Shropshire district. It is of interest to note that *Solenopora* is here accompanied at times by well-marked oolitic structure, and that the same is true of the pebbles with which it is associated in the conglomerate at Habbie's Howe.

Although the marked development of *Solenopora* found in the Stinchar Limestone ceases with the advent of the Benan conglomerate, the genus appears to have survived in the Girvan district into Upper Caradoc times, for Dr. Brown describes a new species (*S. lithothamnioides*) from Nicholson's collection from the Ordovician (? Silurian) beds at Shalloch Mill, where it is said to occur in conical masses the size of a walnut. Specimens of *Solenopora* from Shalloch Mill in Mrs. Gray's collection were obtained from Professor Lapworth's Whitehouse Group.

South of the Scottish border there is, so far as I am aware, only one locality from which Calcareous Algæ have been recorded in rocks of Ordovician age, namely, Hoar Edge in Shropshire. Here large examples of *Solenopora compacta* were obtained in 1888 by Professor Lapworth from the calcareous layers near the base of the Hoar Edge Sandstone. The specimens were handed to Professor Nicholson, who records the circumstance in his description of *S. compacta* in 1888.[1] The form occurs here at the base of the Caradoc beds, and therefore at an horizon which corresponds closely to that of the Craighead Limestone of Girvan.

Professor Lapworth also informs me that he has obtained specimens of *Solenopora* from a limestone in south-west Radnorshire. As the upper portion of the limestone in which it is found contains a Silurian fauna, it is possible that it is here present at a higher horizon, though the constancy with which it occurs elsewhere, in beds of Llandeilo–Caradoc age, would seem to point to the possibility that beds of Upper Ordovician age are also present in this area. In any case its occurrence here is of considerable interest.

Foreign Ordovician.

Outside of Britain the most important development of Calcareous Algæ in rocks of Ordovician age is found in the Baltic Provinces.

Solenopora occurs here in the Upper Caradoc or Borckholm Beds of Schmidt's classification—where it makes up thick beds of limestone—and it is noteworthy that this horizon is practically identical with that at which *S. lithothamnioides* (Brown) occurs at Shalloch Mill.

Other specimens of *Solenopora* were collected by Professor Nicholson in Saak, south of Reyal, from the underlying Jewe Beds, an horizon which must correspond very closely to that of the Craighead Limestone

[1] Geol. Mag., Dec. III, Vol. V, p. 22, 1888.

of Girvan. Speaking of these beds Nicholson & Etheridge remark: "At this locality *S. compacta* not only occurs as detached specimens of all sizes, but it also makes up almost entire beds of limestone; indeed, some of the bands of limestone at Saak look like amygdaloidal lavas, while others have a cellular appearance from the dissolution out of them of the little pea-like skeletons of this fossil."[1]

In Professor Nicholson's collection from these beds Dr. Brown[2] afterwards distinguished two new species, namely, *S. nigra* and *S. dendriformis*. Thus, in the Ordovician rocks of Esthonia, *Solenopora* plays quite as important a part (as a rock-forming organism) as it does in the Girvan district in Ayrshire.

In Norway, again, in the Mjösen district to the north of Christiania, *Solenopora* occurs plentifully in Stage 5 of Kiær's[3] Ordovician series. Here it is very abundant and often builds entire beds, while, further east, at Furnberg, Kiær again records the occurrence of abundant nodules of *Solenopora compacta*, var. *Peachii*.

In addition to *Solenopora*, however, examples of another important group of Calcareous Algæ, the Siphoneæ, occur in great abundance in the Ordovician rocks of the Baltic region, where they play a part in the formation of calcareous rocks scarcely less important than that played by *Gyroporella* and *Diplopora* in the rocks of the Alpine Trias.

The chief forms belong to the family of the Dasycladaceæ, which is represented in our present seas by the recent genus *Neomeris*; they include the genera *Palæoporella*, *Dasyporella*, *Rhabdoporella*, *Vermiporella*, *Cyclocrinus*, and *Apidium*. These algal limestones represent the horizons from the Jewe Limestone to the Borckholm Beds inclusive. They were originally investigated by Dr. E. Stolley,[4] who described their occurrence in the numerous boulders which are strewn over the North German plain in Schleswig-Holstein, Pomerania, Mecklenburg, and Mark - Brandenberg. The facts appear to show that during the deposition of the Jewe and the overlying Wesenberg and Lyckholm Limestones an algal facies obtained which extended from Oeland to Estland, and as far north as the Gulf of Bothnia. But even this area does not represent the full extent of the algal limestone facies in the North of Europe in Upper Ordovician times. In Norway, Kiær[5] has shown by his detailed work in the Upper Ordovician rocks (Stage 5) of the Christiania district, the important part played by the Dasycladaceæ in this area. Here the Gastropod limestone in places forms a 'phytozoan limestone', made up of *Rhabdoporella*, *Vermiporella*, and *Apidium*, associated with a considerable development of oolite.

Again, at Kuven and Valle, in the Bergen district, Reusch[6] and

[1] Geol. Mag., Dec. III, Vol. II, p. 534, 1885.
[2] Geol. Mag., Dec. IV, Vol. I, p. 145 et seqq., 1894.
[3] "Faunistische Uebersicht d. Et. 5": Vid. Selsk. Skr., 1897, No. 3.
[4] Schr. d. naturw. ver. f. Schleswig-Holstein, Bd. xi, 1897, and references there given.
[5] Etage 5 i. Asker. Norges Geol. undersogeles Aarbog, 1902, No. 1.
[6] *Silurfossiler og pressede Konglomerate*, 1882. "*Bømmeløen og Karmøen*": Med. omgiveleser, 1888.

Kolderup[1] have described knolls of crystalline limestone containing abundant remains of *Rhabdoporella* (formerly described as *Syringophyllum*) associated with a Gastropod and coral fauna.

We have, therefore, in Upper Ordovician times, in the North of Europe, one of the most remarkable developments of algal limestones met with throughout the geological succession. In North America Calcareous Algæ are represented in Ordovician times by *Solenopora compacta*, which occurs in the Trenton and Black River Limestone groups, whence it was originally described by Billings under the name *Stromatopora compacta*. It therefore occurs in America at about the same horizon as in Saak and Britain.

We may also note the occurrence of *Girvanella* in the underlying Chazy Limestone. This occurrence was originally described by the late Professor H. G. Seeley[2] under the name of *Strephochetus ocellatus*, but is now generally admitted to be a species of *Girvanella*.[3]

Other forms referred to this genus have also been reported by Schuchert from rocks of undoubted Ordovician age on the east coast of the Behring Straits.[4]

Silurian.

In Britain the only horizon of Silurian age at which Calcareous Algæ play an important part is the Wenlock Limestone. Some years ago Mr. Wethered described the occurrence of *Girvanella* tubes in the beds of this age, especially at May Hill, Purley, near Malvern, and near Ledbury.[5]

Foreign Silurian.

Outside of Britain, however, we find at this period a marked algal development, and this again occurs in the Baltic area, where, especially in the island of Gotland, algal growths contribute largely to several of the limestones and marls. It is an interesting fact that very shortly after the disappearance of the various members of the Dasycladaceæ which were so much in evidence in Ordovician times, we should have the remarkable development of another group of the Siphoneæ, which, quickly reaching a maximum, built up in their turn abundant calcareous deposits. Nodules from these limestones have long been known from Gotland under the name of 'Girvanella Rock', and have been recorded by Stolley[6] in boulders scattered over the North German plain. In 1908, however, Professor Rothpletz showed, in his interesting work on these Gotland deposits,[7] that the forms hitherto alluded to under the term '*Girvanella*' were in reality referable to two different genera. One of these he showed to be a new species of *Solenopora*, to which he gave the name *S. gotlandica* (distinguished from *S. compacta* by the comparatively small dimension of the tubes,

[1] *Et orienterende niveau Bergenskiffe*, *Rhabdoporellenkalk von Kuven und Valle*, Bergens Museums, Aarbog, 1897.
[2] Am. Journ. Sci., vol. xxx, p. 355, 1885.
[3] Geol. Mag., Dec. III, Vol. IV, p. 226, 1887.
[4] See Haug, vol. ii, pt. i, p. 643.
[5] Q.J.G.S., vol. xlix, p. 236, 1893.
[6] Schr. d. naturw. ver. f. Schleswig-Holstein, Bd. xi, 1897, and references there given.
[7] Kungl. Svenska Vet. Akad. Handl., Bd. xliii, No. v, 1908.

which are only about one-quarter of the diameter of the latter species); the other he referred to his genus *Spherocodium*, which he had created in 1890 for certain forms from the Alpine Trias.[1] The survival here of *Solenopora* into beds of undoubted Silurian age is an interesting fact, and would lead us to expect that it may also some day be met with in rocks of a corresponding age in Britain.

Of the different forms of Algæ which occur in these Gotlandian deposits, perhaps the most interesting is *Spherocodium*, which, as shown by Dr. Munthe,[2] occurs at several horizons in the succession. It first makes its appearance in the marl immediately overlying the Dayia Flags — approximately of Lower Ludlow age — where it occurs in considerable masses. In external appearance these resemble very closely nodules of *Ortonella* from the Lower Carboniferous rocks of the North-West of England; some of the nodules appear to have reached a diameter of 4 cm. The marl is overlain by sandstone and oolite, which are succeeded by an argillaceous limestone rich in nodules of *Spherocodium gotlandicum* and well exposed at Grötlingbo, where it is closely associated with oolite. Among the fossils of this limestone *Spherocodium* itself plays the most important rôle.

In the overlying 'Iliona Limestone' *Spherocodium* is decidedly rare, and its place is taken by *Spongiostroma*. As will be pointed out later, there appears to be no good reason why *Spongiostroma* may not be indirectly due to the presence of algal growths; but whatever may be the final position assigned to it, there can be no doubt as to its importance as a rock-building form in the Iliona Limestone of Gotland. We may conclude, therefore, that the development of the *Spherocodium* beds of Gotland probably occupied originally nearly as wide an extension in the Baltic area as did the *Rhabdoporella* limestones during the Ordovician Period.

With regard to other occurrences of Calcareous Algæ in Silurian rocks, it will be sufficient to note that of *Girvanella* in the Silurian limestones of Queensland, recorded by Mr. G. W. Card in 1900,[3] and more recently by Mr. Chapman from Victoria.[4]

Quite recently Mr. R. Etheridge, jun., of Sydney,[5] has described "an organism allied to *Mitcheldeania* from the Upper Silurian rocks of New South Wales"; the figures given, however, and the description are not convincing that his identification can be accepted. The size of the tubes, which are from five to six times as large as those of *M. gregaria*, would alone appear to remove this organism from Mr. Wethered's genus and also possibly from the Calcareous Algæ.

Devonian.

So far as I am aware, there is only one recorded occurrence of Calcareous Algæ from the Devonian rocks of Britain—namely, in the Hope's Nose Limestone of Devonshire, from which Mr. Wethered has described aggregations of tubules resembling *Girvanella*, but in a very poor state of preservation.

[1] Bot. Cent., vol. lii, p. 9, 1890.
[2] Geol. Foren. Forh. Stock., Bd. xxxii, Hft. v, p. 1397, 1910.
[3] Bull. Geol. Surv. Queensland, 1900, No. 12, pp. 25–32, pl. iii.
[4] Rep. Austr. Assoc. Adv. Sci., 1907–8, pp. 377–86, pls. i–iii, 1908.
[5] Rec. Geol. Surv. N.S. Wales, vol. viii, pt. iv, p. 308, pl. xlvii, 1909.

Foreign Devonian.

On the Continent the reported occurrences are, so far, equally poor. At the same time, the cursory examination which I was able to make of the thin sections of the Devonian limestones exhibited in the Brussels Museum leads me to expect that a careful investigation of the Belgian Devonian limestones will yield other examples besides *Spongiostroma*.

Carboniferous.

We now reach the period in Palæozoic times when Calcareous Algæ attained their maximum development in England, a development rivalling that which obtained in the Ordovician rocks of Scotland and the Gotlandian of the Baltic area. The genera represented include *Girvanella*, *Solenopora*, and *Mitcheldeania*, while in addition to these there occur several lime-secreting organisms which, though still undescribed, will, I think, ultimately come to be included among the Calcareous Algæ. The most interesting of these organisms I have recently figured from the Lower Carboniferous rocks of Westmorland, where it forms a definite zonal horizon or 'band'.[1] For this form, on account of its stratigraphical importance and for facility of reference, I propose the generic name of *Ortonella*.[2]

Again, at the same horizon in the North-West Province I have frequently noticed concretionary deposits of limestone which occur as finely laminated masses, the laminæ often lying parallel to the general direction of the bedding planes, which on microscopic examination show no definite or regular structure, but have every appearance of being of organic origin. Many of these puzzling forms resemble very closely the somewhat obscure structures found in the Visean limestones of the Namur basin in Belgium, of which beautiful thin sections are displayed in the Natural History Museum at Brussels,[3] and which Gürich has described and figured under various names—*Spongiostroma*, *Malacostroma*, etc., and which he has included under a new family, the Spongiostromidæ,[4] and a new order, the Spongiostromaceæ. I must confess that neither in the original sections nor in the beautiful illustrations that accompany his work can I see any grounds for referring these structures to the Protozoa.

As regards the British specimens, I have long regarded them as due, directly or indirectly, to the work of Calcareous Algæ, partly on account of their intimate association with well-developed examples of these organisms and also on account of the entire absence of Foraminifera and other detrital organisms wherever this structure occurs. As, however, I have little doubt that they are closely connected in their mode of origin with the Belgian specimens, we may conveniently speak of them under the general term *Spongiostroma*.

[1] Q.J.G.S., vol. lxviii, pl. lxvii, fig. 2, 1912.

[2] From Orton, a village between Shap and Ravenstonedale, where this organism occurs in great abundance.

[3] One of these is also exhibited at the Jermyn Street Museum.

[4] Mém. du Musée Roy. d'Hist. Nat. de Belgique, tom. iii, 1906.

Some of the best examples known to me occur associated with *Ortonella* in the '*Productus globosus* band' near the summit of the '*Athyris glabristria* zone' in the Shap district. They occur here in considerable masses, often many inches in thickness, and form undulating layers parallel to the bedding, and somewhat resembling huge ripple-marks. In all cases they appear to be due to the precipitation of carbonate of lime in the neighbourhood of algal growths. I have also met with similar deposits, not only at other horizons in the Lower Carboniferous rocks of the North of England, but also in the Forest of Dean and in the rocks of the Avon Gorge; while quite recently Mr. C. H. Cunnington has sent me examples from several horizons in the Carboniferous Limestone of South Wales.

Girvanella.—This organism appears to play a considerable part in the formation of calcareous deposits in the Lower Carboniferous rocks of Britain. Its presence in these rocks was first suggested by the late Professor Nicholson,[1] who wrote: "I have found some of the Carboniferous Limestone of the North of England to contain largely an ill-preserved organism, which will, I think, prove to be referable to *Girvanella*." This prophecy has turned out to be fully justified, not only as regards the North of England, but also in the case of the Lower Carboniferous beds of other districts. In 1890 Mr. E. Wethered described[2] two new forms of this genus from the Lower Carboniferous rocks of the Avon Gorge and Tortworth, viz. *G. incrustans*, with tubes having a diameter of 0·1 mm., and *G. Ducii*, with a diameter of ·02 mm. Mr. Wethered appears to rely chiefly on the size of the tubes for the differentiation of these species, but as this distinction was made at the time when *Girvanella* was still considered to belong to the Rhizopods, and as the size of the tubes frequently varies in the same specimen, it is doubtful whether these species can be maintained. Mr. Wethered's specimens were obtained from the limestone near where the Bridge Valley Road joins the river bank, apparently at the base of Dr. Vaughan's Upper Dibunophyllum Zone. The position of this limestone is of interest, as it appears to correspond very closely with the horizon of the '*Girvanella* Nodular Bed', which forms a well-marked band at the base of the Upper Dibunophyllum Zone throughout the whole of the North and North-West of England. Indeed, I have traced this band at intervals from the neighbourhood of Ford, near the Scottish Border, southwards through Northumberland and the Pennine area to Penygent, and from the west coast at Humphrey Head through Arnside and Shap to the east coast near Dunstanburgh. These organisms must, therefore, have flourished at this period over an area of at least 3,000 square miles in the North of England alone.

The best exposure showing the important development of these *Girvanella* nodules is to be found on the dip slopes forming the eastern shore of Humphrey Head in Morecambe Bay, where the base of the Upper Dibunophyllum Zone is exposed over a considerable area.

[1] GEOL. MAG., Dec. III, Vol. V, 1888.
[2] Q.J.G.S., vol. xlvii, p. 280, pl. xi, figs. 1, 2, 1890.

(*To be concluded in the December Number.*)

IV.—The Plutonic Rocks of Garabal Hill.

By B. K. N. Wyllie, M.A., B.Sc., and Alexander Scott, M.A., B.Sc., Carnegie Research Scholars in the University of Glasgow.

THIS complex of igneous rocks lies between Ardlui, at the head of Loch Lomond, and the head of Loch Fyne. In 1892 it was the subject of a fairly exhaustive paper by Teall & Dakyns,[1] but in view of a number of new facts which we have discovered we venture to submit a re-examination of the problems connected with the complex. The mass is broken by a north-east fault. The country to the west of this fault is mainly porphyritic granite and tonalite; to the east there is tonalite and also more basic diorite and ultrabasic rocks. We shall concern ourselves mainly with the basic and ultrabasic groups, as they are somewhat unusual in the "Newer Plutonic Rocks of the Highlands".

Ultrabasic Rocks.

The ultrabasic rocks form several small isolated outcrops along a line running N.N.E. from Loch Garabal, and passing about 200 yards to the east of Lochan Beinn Damhain (Loch Ben Davain). The largest of these covers about one-eighth of a square mile, and lies immediately north of Loch Garabal.

About 200 yards east of the north end of Lochan Beinn Damhain, and near a little lochan, another exposure appears, followed to the north by two others. The total area is about 200 square yards. A mere patch is also found about 100 yards south of the small lochan, and further north still, at a place 400 yards north of the highest point of Garabal Hill, a congeries of weathered blocks probably indicates another minute outcrop. The Geological Survey map of this area claims a long narrow strip, further north than our last-mentioned exposure, as peridotite. But of this no evidence was found beyond a few scattered boulders.[2] The map in the paper by Teall & Dakyns includes likewise some peninsulas and islands of schist in the plutonic rocks. A careful examination of these localities proved the outcrops to be partly schist and partly diorite, the field relations of the two, however, indicating that the schist represents the residuum of the original 'roof', which has so far escaped total denudation. A similar schist roof has been recorded by Barrow in Glen Tilt.[3] It is noteworthy that this chain of exposures is practically coincident with the line which separates the diorites from the later tonalite. But we have not been able to decide whether the ultrabasic masses are actually wedged in between these two or enveloped in the diorite close to its margin. On the diorite side

[1] "Plutonic Rocks of Garabal Hill and Meall Breac": Quart. Journ. Geol. Soc., xlviii, pp. 104–21, 1892.

[2] The sketch-map of Teall & Dakyns is reproduced in Hatch's *Petrology* (p. 303), but with the omission of all the peridotite areas we have mentioned, except the one we failed to find, while the positions of Garabal Hill and Garabal Cottage are interchanged.

[3] *Geology of Upper Strathspey*, etc. (Mem. Geol. Surv. Scotland), 1913, p. 72.

the junction is plain, but on the other side it is obscured in every instance by peat, though tonalite is exposed in mass close by and intersects both the others in dykes and strings.

The predominant type among the ultrabasic rocks is a pyroxenite, with large bronzy diallage crystals which often weather out like phenocrysts. Olivine is seldom absent; it occasionally equals the pyroxene in amount; and in places we find veins of pure serpentine, representing the end product of this replacement. All intermediate stages are found between pure olivine (serpentine) rock and pure pyroxenite. In one place an olivine-bearing rock is found forming a vein 6 inches thick in a pyroxenite.

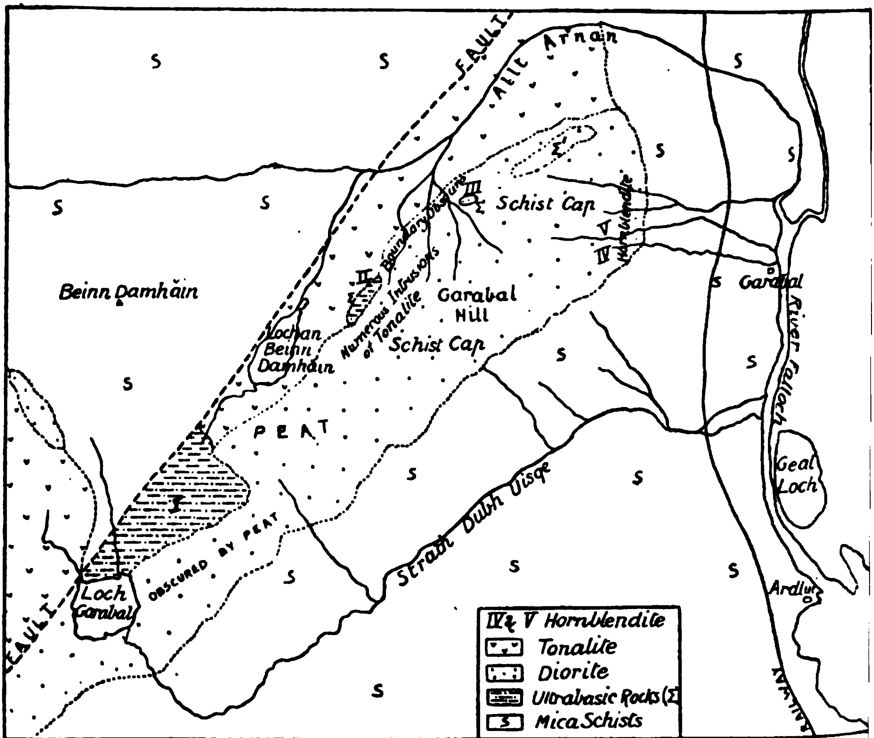

FIG. 1. Sketch-map of the basic and ultrabasic rocks of Garabal Hill. Scale 1·7 inches = 1 mile. Note: Σ′ marks the area mapped by Teall & Dakyns as peridotite, but the only evidence of peridotite that we could find was some scattered boulders.

A rock of entirely different appearance occurs in large masses at locality ii (see Map, Fig. 1) and in little strings at Loch Garabal. This is composed of glossy coal-black crystals of hornblende of a granular texture, with grains varying up to ½ inch in diameter. At locality ii (see Fig. 1) this rock is found always intervening between the diorite and the pyroxene-olivine rocks. It is sometimes penetrated by the diorite in such a way that the two are hard to distinguish. In thin section this rock is found to be practically a hornblende rock. The hornblende is brown, with pleochroism from dark brown to light yellow.[1] The crystals are uniform in size and packed closely together with few interstices. The cores of the crystals are very commonly of diallage, with flecks of hornblende arranged symmetrically throughout them. These pyroxene cores, again, show a sprinkling of parallel-orientated schiller rods. Even in crystals which have no colourless core these schiller patches occur, and the explanation is obvious that all the hornblende was formerly pyroxene.

Grains of rhombic pyroxene (enstatite) occur, sometimes in clusters, more often separately. Generally they are seen to be an earlier formation, the hornblende being moulded round them, or enclosing them. Interstitial felspar is scanty or absent. But veins occur which are more felspathic, the felspar then amounting to about 10 per cent of the whole. Where determinable, this felspar presents the characters of andesine. Grains of apatite are also an important accessory, and a few scattered flakes of biotite can always be distinguished.

This rock seems to be unique in Scotland, and as we have not been able to parallel it elsewhere, we propose to refer to it for the present as Davainite, which we therefore define as a rock consisting essentially of brown hornblende, which is paramorphic after pyroxene, the total amount of other minerals such as hypersthene and felspar being small. The name hornblendite we reserve for an end-member of the diorite series, to be mentioned hereafter.

The other ultrabasic rocks show, under the microscope, diallage, enstatite, olivine, brown hornblende, biotite, and black oxides, with a constant but small amount of apatite. Olivine is generally serpentinized where it is present in considerable amount. Biotite is almost always present, though never abundant. Enstatite is generally subordinate to diallage, but usually fairly abundant. Hornblende is the same brown variety described in Davainite. Here also it seems to be new-formed from pyroxene, and all stages of the replacement are found. Some specimens from the centre of the Loch Garabal mass show no hornblende. It seems to increase in amount towards the margins. Locally, a small amount of basic plagioclase (bytownite) appears.

Diallage is by far the most abundant constituent. It occurs in large crystals, giving the rock a porphyritic aspect. In one case this porphyritic structure is quite real, as the interstitial matter is granular olivine, enstatite, and smaller diallage crystals. The rock in which this is found is a vein, intrusive into a finer-grained pyroxenite, so that the phenocryst explanation is reasonable. The diallage crystals are commonly rendered dusty or dense by parallel-orientated schiller inclusions.

[1] The pleochroism of the hornblende is: X, light yellow; Y, dark brown; Z, reddish brown.

Reckoning the hornblende as equivalent to pyroxene, we may state the rock-types represented, as follows:—

PYROXENITE.
(Diallage–enstatite.)
|
Lherzolite and Wehrlite.
(Di. En. Ol.) (Di. Ol.)
|
Pyroxene–peridotite.
(Ol. with little Di. or En.)
|
Olivine rock.

[(Gabbro) + Norite.]

Picrite and Enstatite-picrite.
(Di. Ol. Felspar.) (Di. En. Ol. Felspar.)

We have not found any rock rich enough in felspar to be called gabbro, though the felspathic veins in davainite come very close to that. A norite has been recorded at locality iii (Map, Fig. 1), but this is a hybrid rock and will be mentioned later.

DAVAINITE.

We have now to substantiate at greater length our contention that the brown hornblende here found is altered diallage, and, consequently, that the rock we designate as davainite is the equivalent of the pyroxenites. There are two possibilities: (1) the change may have

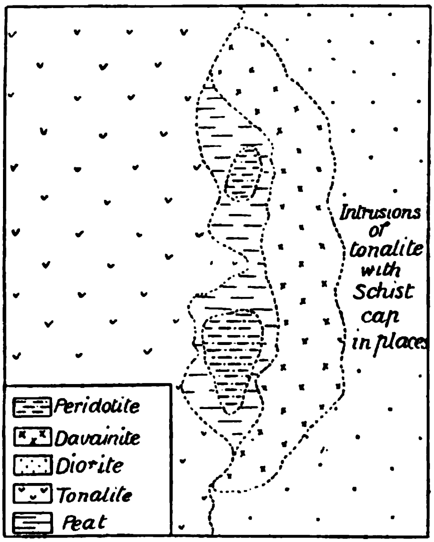

FIG. 2. Sketch-map showing the occurrence of Davainite at locality ii. (See Map, Fig. 1, *ante*, p. 500.)

occurred during cooling, and may denote a transition temperature below which hornblende is stable, and above, diallage; (2) the change may be due to some kind of annealing of the diallage rocks by the later diorite magma, which, as we have noted, is in intimate contact with the davainite at locality ii.[1] (See Map, Fig. 1.)

[1] By annealing we mean reheating to a temperature which is lower than the melting-point of pyroxene, but which lies in the region where hornblende is the stable modification.

The significant phenomena are these: (1) cored hornblende crystals, showing either actual diallage, or the diallage schiller structures, in their centres; (2) partly pleochroic diallage crystals, retaining the pyroxene cleavage and extinction; (3) amphibolized veins meandering through diallage crystals.

The last case especially can hardly be explained on the 'simultaneous' view, whereas the 'secondary' theory explains all equally well. Moreover, it may be doubted if a mere equilibrium change during the original cooling suffices to account for the formation of a strongly coloured and strongly pleochroic amphibole from a practically colourless pyroxene. Amphiboles in general are reputed to contain hydroxyl, whereas pyroxenes do not. It is possible that the introduction of hydroxyl into a molecule gives it different optical properties: for instance, amphiboles are pleochroic; pyroxenes, as a rule, are not. But the case we have at present seems to demand still more than this; it is difficult to associate the marked brown of this hornblende with anything but a marked increase in the ferric-oxide content. We suggest, therefore, that hydroxylation and oxidation have been effected by heated vapours, and general reheating, from the subsequent diorite magma.

We offer such chemical evidence as we possess in support of this idea. A specimen of davainite was analysed, but as it was more felspathic than the typical rock we have recalculated the analysis to give the proportions of the femic constituents only:—

	I.	Ia.	II.	III.	IV.	V.
SiO_2	43·53	37·00	38·6	44·94	31·84	41·01
TiO_2	1·90	2·80	—	—	—	·66
Al_2O_3	7·24	—	3·7	4·84	1·37	5·00
Cr_2O_3	—	—	—	·76	—	·14
Fe_2O_3	11·10	16·40	7·6	4·64	15·63	5·52
FeO	8·70	12·80	7·8	6·75	14·25	8·66
CaO	10·19	14·00	7·7	14·70	·91	4·43
MgO	11·51	17·00	27·7	23·16	33·10	29·92
K_2O	1·39	—	·2	—	—	·25
Na_2O	2·88	—	—	—	—	·98
H_2O+	1·34	—	6·4 (H₂O+, H₂O−, CO₂)	1·48 (H₂O+, H₂O−, CO₂)	2·49 (H₂O+, H₂O−, CO₂)	4·95
H_2O-	·43	—				·43
CO_2	nt. fd.	—				·76
P_2O_5	trace	—	—	—	—	·10
	100·21	100·00	99·8	101·23	99·59	100·53

I. Davainite.
Ia. ,, recalculated.
II. Wehrlite (somewhat serpentinized), L. Garabal, anal. J. H. Player.[1]
III. ,, } Koswinsky Kamen, North Ural.
IV. Dunite }
V. Peridotite, Dunan Liath, Ross-shire, anal. W. Pollard.[2]

[1] Teall & Dakyns, loc. cit., p. 115.
[2] *Geology of Ben Wyvis*, etc. (Mem. Geol. Surv. Scotland), 1912, p. 127.

We note (1) that the lime content of davainite is on a par with that of the wehrlite analyses, while the comparatively low magnesia percentage is consistent with the absence of olivine. (2) The amounts of Fe O, Ti O_2, $Fe_2 O_3$ in davainite would correspond with 20 per cent of magnetite and ilmenite in the rock, if all were so present. But 3 or 4 per cent is all that can be allotted to these minerals. Hence it appears that the hornblende of the rock must contain a large proportion of Fe O and $Fe_2 O_3$ and probably Ti O_2. (3) $Fe_2 O_3$ is decidedly in excess of Fe O in davainite, which is the reverse of their normal relation in diallage-bearing rocks. We conclude that our assumption of oxidation is supported by this analysis.

We have no evidence of any considerable action on the ultrabasic rocks by the diorite magma other than this metamorphism of pyroxene: there has been no wholesale absorption, since quartz-bearing diorites are the rule close up to the contact; though the absence of olivine from the border-zone of the ultrabasic mass—at least, in all the sections of davainites we have cut—makes it possible that a slight amount of siliceous material has penetrated there. This is supported by the presence in davainite of a considerable amount of rhombic pyroxene; the clustered grains mentioned above will in that case represent original olivine. It is all the more significant that some of the rhombic pyroxene seems to be new-formed and of a different composition from that of the unchanged peridotites.

It was mentioned that among the rock-types a norite was found. This occurrence will now be described, as it is pertinent to the foregoing discussion. The rock in question forms thin irregular veins in the peridotite at locality iii (see Map, Fig. 1). In thin sections these are seen to be composed of felspar and pyroxene, with granular aplitic texture. Felspar forms about 80 per cent of the bulk except where the femic minerals are clotted together—and that always happens close to the surrounding peridotite. It consists of orthoclase, with a basic plagioclase (andesine or labradorite), the latter being far in excess of the former. In the whiter parts a few grains of quartz can be detected.

Of the femic minerals, the most striking is a richly pleochroic hypersthene, which builds large idiomorphic crystals, and is much in excess of the others, which are colourless or faintly greenish enstatite and diallage.

Now the surrounding rock is a peridotite, containing diallage and colourless non-pleochroic enstatite, with scattered flakes of mica. Diallage and enstatite in the two rocks are identical, and the vein rock presents in the same way a few stray pieces of biotite. The co-existence in the same melt of two different members of the iron-magnesium metasilicate minerals, which form a continuous series of solid solutions, is obviously impossible. Hence one of them must be xenocrystic, and that one can only be enstatite. The explanation is therefore plain: the vein rock is a hybrid, formed by partial solution of peridotite matter in a quartz-aplite, such as are abundantly associated with the later tonalite magma. Enstatite has remained unattacked. The solution of olivine has produced hypersthene, with elimination of nearly all the free silica of the solvent. Diallage has been only partly decomposed, but that partial decomposition has set free a certain amount of lime, with the result that plagioclase is more basic than is commonly the case in aplites. It should be mentioned also that the diallage shows the usual alteration to brown hornblende, though that is not nearly so advanced as in the davainite.

When the case is considered from the purely chemical point of view, this 'selective solution' is easily understood. Olivine, being an orthosilicate, is unsaturated with respect to silica and hence would be easily attacked, the resultant product being the metasilicate, hypersthene ($Mg\,Fe\,Si_2\,O_6$). Enstatite, a metasilicate, is saturated with silica and hence remains undissolved, unless the temperature is very high. Diallage, while chiefly composed of metasilicate molecules, also contains compounds of the type $R''\,Al_2\,Si\,O_6$, and these can take up more silica to form types such as $R''\,Al_2\,Si_2\,O_6$. Thus the formation of anorthite, and consequent basification of the plagioclase, may be expressed by the equation

$$Ca\,Al_2\,Si\,O_6 + Si\,O_2 \longrightarrow Ca\,Al_2\,Si_2\,O_8.$$

Tonalite and Diorite.

Garabal Hill itself is composed of a series much more acid than those described above. There are clearly two separate rock masses, the earlier one comprising diorites with a considerable variety of structure and mineralogical composition, while the later one is a more or less uniform tonalite. The latter is obviously intrusive into the former, as it penetrates both the diorites and davainites in numerous veins of varying thickness, and generally with sharp junctions and no commingling on the margins. The tonalite consists mainly of deep-brown strongly pleochroic biotite and zoned oligoclase in a matrix of quartz, orthoclase, and plagioclase. The quartz and felspar contain numerous inclusions of apatite, zircon, and sphene, while in the ground-mass sporadic crystals of sphene and muscovite are found. In the region of Garabal Hill the rock is even-grained and not particularly coarse, although in one or two places mica 'clots' are found, consisting of aggregates of biotite, with strong absorption, and subordinate interstitial quartz and felspar. These probably represent foreign material which has been absorbed and completely recrystallized. Near Meall Breac, to the west of the fault and in the area mapped by the Geological Survey as tonalite, a much coarser rock is found. It differs from the tonalite described above, not only in texture but also by the presence of green hornblende, equalling in amount the biotite, and of fairly large crystals of sphene. It closely resembles some of the more acid diorites and should probably be classed with them.

The diorites differ considerably in the different localities, and grade from fairly acid, quartz-bearing rocks to pyroxene diorites and hornblendites. The chief constituent minerals are quartz, orthoclase, plagioclase, mica, hornblende, pyroxene and sphene. The plagioclase in the more basic varieties is labradorite-andesine, but oligoclase is found in the 'acid' rocks. The quartz and felspar are rich in inclusions of apatite, zircon, and occasionally rutile. The mica is generally biotite with strong pleochroism and absorption, and often altering to chlorite. Sphene occurs in pleochroic yellow crystals as well as in the common granular form.

The pyroxene is a pale-green diopside with an extinction of 30°–40° and showing generally schiller inclusions. Occasionally aluminous pyroxenes are also found. The amphibole is the common green hornblende with low extinction and strong pleochroism from light to dark green. It occurs partly as the margins of pyroxene crystals, or as a paramorphic replacement of these, and partly as original crystals. It undergoes alteration in two ways, sometimes to aggregates of pale-coloured actinolite, sometimes to a brown hornblende with a complicated pseudo-schiller structure, which will be described later.

One of the more acid types occurs on the south-east slopes of Garabal Hill, and consists of quartz, felspar, and green hornblende, with subordinate biotite, and chlorite. The felspathic minerals greatly preponderate, though the amount of quartz is comparatively small. Sphene is common, and is usually altering to ilmenite or leucoxene. A much coarser rock with abundant sphene and apatite, and no quartz or biotite, is found to the east of Loch Garabal. The felspar is nearly all saussuritized, while the original hornblende is replaced by fibrous aggregates of actinolite or tremolite. Occasionally traces of original pyroxene cores surrounded by paramorphic hornblende are found. In places this passes to a quartz-bearing rock with a fair amount of biotite, while the hornblende assumes a more prismatic habit than usual. This rock is probably some kind of 'schlieren', as it is more acid than the surrounding rocks, and at other localities, which will be described later, obvious schlieren are found, containing amphibole of similar habit. The diorite which forms the eastern margin of the main davainite area somewhat resembles the Loch Garabal rock. It is finer in grain than the latter, but the felspar is partly replaced by saussurite and the hornblende by actinolite. Quartz is absent, while the presence of original pyroxene is indicated by hornblende aggregates containing traces of original diallage or diopside. A few small flakes of biotite, which is probably secondary, are also present. On the ridge north of Garabal Hill a rock occurs which seems to be the most basic of the diorites; it probably approaches a gabbro in chemical composition. It is a medium to coarse-grained aggregate of plagioclase, hornblende, and pyroxene, with subordinate orthoclase and biotite and no quartz. The felspar is a comparatively unaltered labradorite exhibiting good twinning, while the hornblende is a green mineral more or less completely altered to brown, and the pyroxene is the pale-green diopside common to the diorites. The felspar occurs in coarsely granular aggregates filling up the interstices between the ferromagnesian minerals. Mineralogically the rock might also be described as a hornblende-gabbro.

In the neighbourhood of loc. iii (see Map, Fig. 1) numerous veins and clots occur, rich in epidote. Sections were made of specimens from one such vein which showed some considerable variety. The centre of the vein consisted of epidote, vesuvianite, and spinel, with occasional crystals of hornblende. The epidote occurs as an even-grained mass of subhedral crystals with pleochroism from yellow to pale-green and somewhat larger in size than the crystals found in similar veins in Cornwall. Minute crystals of blue magnesia-bearing spinel are found bordering the epidote. In the centre rock the vesuvianite occurs interstitially, and is obviously the last mineral to crystallize, but towards the margins aggregates of large hornblende and idocrase crystals occur, both being subhedral. The vesuvianite crystals are brownish to colourless, with occasional lamellar cleavage and the characteristic low double refraction. The amphibole resembles the green hornblende of the diorite, but is obviously changed in places to a mineral resembling glaucophane, while elsewhere epidote and vesuvianite have developed at its expense, the crystals being very much corroded round the margin. The vein is bordered by a narrow band of typical hornblende schist, consisting of blue-green amphibole, quartz, orthoclase, and albite, with occasional patches of the original dioritic hornblende in a state of partial alteration.

Epidosites have been described by the Geological Survey from both sedimentary and igneous schists and gneisses in the Lizard district[1] and also from the Kilmartin district, where they occur in epidiorites.[2] Those occurring in the sedimentary rocks are generally quartzose, and are probably produced by the shearing of rocks which were weathered before being metamorphosed. The 'igneous' epidosites, however, are assumed to be due to chemical segregation during movement, and it is this explanation which seems to be most applicable in the case of the Garabal Hill rock. The epidote rocks of the latter area differ from those of Cornwall by the almost complete absence of minerals other than the lime-bearing ones—the amount of spinel is exceedingly small. They seem to have formed along shearing planes in the diorite, where the country rock has undergone strain of such intensity that it has been rendered completely fluid.[3] The neighbouring rock is a hornblende-pyroxene-diorite with a basic plagioclase as the only felspathic mineral. The shearing has resulted in chemical interaction between the felspar and the ferromagnesian minerals, with the formation of epidote. Several cases of the production of epidote as a contact mineral between felspar and hornblende[4] have been recorded, and it seems probable that the reaction between these two minerals in a fluid state in presence of water is comparatively simple. The crystals on the margins would be easily attacked, the large hornblendes which are partly corroded being those which have been incompletely dissolved. This solution effect would also explain the partial aggregation of the vesuvianite at the margins, as the latter is richer in lime and poorer in alumina than epidote, while hornblende is

[1] Flett in *Geology of Lizard and Meneage* (Mem. Geol. Surv. England), 1912, pp. 36, 46.

[2] Flett in *Geology of Seaboard, Mid-Argyll* (Mem. Geol. Surv. Scotland), 1909, pp. 47–50.

[3] At several other places on Garabal Hill evidence of faulting is found; thus at loc. iv (see Map, Fig. 1) a line of brecciated diorite with numerous quartz-veins can be traced for about 20 yards.

[4] G. H. Williams, Bull. U.S. Geol. Surv., 1886, No. 28, p. 31; F. D. Chester, Bull., 1890, No. 58, p. 35.

likewise richer in lime and poorer in alumina than felspar. The vesuvianite aggregates, therefore, are the product of the solution of hornblende crystals in a fluid so viscous that but little diffusion could take place. The interstitial vesuvianite arises through a combination of two causes: (1) The ratio of lime to alumina in the diorite is, as stated above, higher than that required for the formation of epidote. (2) The diorites contain appreciable amounts of magnesia and alkalis. Part of the former crystallizes as spinel, but the remainder, together with the alkalis, would enter the vesuvianite molecule, which can have up to 6 per cent magnesia and 2 per cent alkalis, while epidote rarely has more than a trace of either.

(*To be concluded in our next Number.*)

V.—On Saturated and Unsaturated Igneous Rocks.

By Professor S. J. Shand, D.Sc., Ph.D., F.G.S., Victoria College, Stellenbosch, South Africa.

OF the various minerals which enter into the composition of igneous rocks, about one-half are capable of forming in presence of free silica, as is shown by their association in rocks with quartz and tridymite. These may, for the present purpose, be termed *saturated* minerals; they include some of the most highly silicated compounds of their respective metallic elements. The remaining rock minerals do not appear in association with free silica, and may be presumed to be incapable of stable existence in its presence; they are mostly the less highly silicated compounds of the same metallic elements which enter into the former group. These may, for the present purpose, be termed *unsaturated* minerals. The unsaturated character of any mineral in the latter group is not affected by the temperature and pressure at which crystallization takes place; this is shown by the fact that quartz and the minerals referred to are mutually exclusive both in plutonic and in effusive rocks. In the case of sodium, potassium, calcium, and magnesium the formation of saturated or unsaturated minerals appears to depend only on the amount of silica available in the magma. Aluminium, ferrosum, and ferricum, elements of feebly basic character, have their combinations largely determined for them by the more strongly basic elements, with which they tend to form either complex molecules or mix-crystals.

In the following table the saturated and unsaturated compounds of each element are placed as far as possible in apposition:—

Saturated.	*Unsaturated.*
Orthoclase.	Leucite.
Albite.	Nephelite.
	Sodalite.
	Nosean.
	Analcite.
	Cancrinite.
Anorthite.	Hauyne.
	Melanite.
	Melilite.
Pyroxenes. }	Olivine.
Amphiboles. }	Pyrope.
Micas. }	Picotite.

Saturated.	*Unsaturated.*
Tourmaline.	
Spessartite.	
Topaz.	Corundum.
Titanite.	Perovskite.
Magnetite.	
Ilmenite.	
Apatite.	
Zircon.	

I anticipate that objection may be raised to one or two of the minerals classed here as unsaturated. The first of these is olivine. A few dolerites and basalts have been described as containing both quartz and olivine, but I think the experience of most petrographers will show that this association is quite unusual. I have never come across an instance of it in the field, and I think it highly probable that the explanation of such an unusual association is that the quartz is not of magmatic origin. The only example of a quartz-olivine rock in my collection is the 'melaphyre' of Albersweiler in the Rhenish Palatinate, which contains small 'phenocrysts' of quartz. An examination of this rock decidedly suggests that the supposed phenocrysts are really xenocrysts. They are just as often aggregates as single grains, and they are always anhedral, with rounded, fretted outlines. But to be sure of this one would require to study the rock in the field. Harker[1] and Mennell[2] have both described occurrences of quartz xenocrysts within basalts and dolerites. In the cases described by Harker, basalt sills which were invaded by granophyre have been acidified and impregnated with quartz xenocrysts by the latter. In the dolerite intrusions in the Matopo granite, which Mennell describes, the quartz xenocrysts and the interstitial micropegmatite of the dolerites are due to absorption of granite. In at least one of these intrusions olivine is present. As the latter is a mineral of very early crystallization it is evident that the absorption or incorporation of quartz may occur too late to prevent the partial separation of magnesium in the form of olivine, and hence the two minerals may exist side by side. According to this view such quartz-bearing dolerites would be hybrid rocks, not true magmatic products. For further evidence bearing upon this point I must await the judgment of those who have the opportunity of studying such exceptional rocks in the field.

As regards corundum, I know of no instance where it occurs in association with quartz in igneous rocks; its common hosts are nephelite-syenites, anorthosites, and peridotites. Any excess of alumina over bases in the quartz-bearing rocks always seems to appear as muscovite or topaz, not as corundum.

It may seem strange that garnets should fall into two contrasted groups, the spessartites (and probably the almandites as well) being regarded as saturated while others (melanite, pyrope) are unsaturated; yet this is simply an expression of observed facts of distribution. In my own experience of melanite rocks in Sutherlandshire,[3] where

[1] *Tertiary Igneous Rocks of Skye* (Mem. Geol. Surv., 1904).
[2] "Basic Dykes and Rock Genesis": Geol. Mag., 1911.
[3] Trans. Edinb. Geol. Soc., 1910.

quartz syenites pass insensibly into melanite syenites, the first trace of melanite does not appear until the last trace of quartz has been lost, although there is no immediate change in total lime content.

Anorthite, too, appears at first sight to occupy an anomalous position; it is an orthosilicate occurring in a group which is mainly composed of polysilicates and metasilicates. But calcium metasilicate (wollastonite) is incapable of independent existence under magmatic conditions, hence the orthosilicate is the stable form even in quartz-bearing rocks. True quartz-anorthite rocks are probably rare, but the anorthite molecule must have been present as such in the parent magma of every quartz-plagioclase rock.

Magnetite and ilmenite are of course completely unsaturated as regards silica, from the chemical point of view, but as both are capable of stable existence in the presence of free silica under magmatic conditions, they rank here as saturated minerals. (Should it be felt that this new use of a common term is liable to be misunderstood, the reader may at his pleasure read *sated* and *unsated* in place of 'saturated' and 'unsaturated'.)

A rock which contains only saturated minerals may be termed a *saturated rock*; one which contains only unsaturated minerals may be termed an *unsaturated rock*. It will also be desirable to distinguish *partsaturated rocks* (e.g. phonolites, olivine-dolerites) from wholly unsaturated ones; as a general term to cover both partsaturation and unsaturation we may employ *undersaturation*. Any rock which contains free quartz or tridymite of magmatic origin will be termed *oversaturated*.

These distinctions are by no means trivial; they have a very definite chemical significance which has a bearing upon the reaction of the magma towards invaded rock masses, and hence upon magmatic differentiation. They are also capable of useful application in the classification of igneous rocks.

1. An undersaturated magma (i.e. one which on solidifying would give rise to a partsaturated or unsaturated rock) is capable of entering into chemical combination with the silica of invaded rock masses. The reactions thereby induced would be exothermic, and would tend to raise the temperature of the magma. The amount of heat to be gained in this way does not seem to be susceptible of direct measurement at the present time: the difficulties to be overcome would be very great, but as silicic acid is known to be an exceedingly powerful acid at high temperatures, it is probable that the heating effect of the reaction would be considerable. The access of heat produced in this way would in turn enable the magma to perform a further amount of work in the way of mechanical solution.

2. A saturated or oversaturated magma (i.e. one which on solidifying would give rise to a saturated or oversaturated rock) is incapable of combining chemically with silica; its action on the quartz of invaded rocks must be confined to physical solution, which will lower the temperature of the magma.

Other things being equal, then, an undersaturated magma must have a greater action upon invaded siliceous rocks than a saturated or oversaturated magma; as a result of such action it would tend first to saturate itself chemically, then to oversaturate itself in the physical way. (Reactions with constituents other than silica are for the moment disregarded.) As a consequence of the greater activity of an undersaturated magma, one would expect to find greater variation, both chemical and mineralogical, within a body or complex of undersaturated rocks than in a saturated or oversaturated body or complex. This deduction seems to be confirmed by the enormous number of varietal names which have been coined for different facies of the undersaturated rocks.

3. Towards the aluminous constituents of invaded rocks it would seem that there would be little difference in the behaviour of saturated and undersaturated magmas. The change by which aluminium silicates are converted into micas and felspars, a change for which the field evidence is overwhelming in amount, could not be effected any more readily by a felspathoidal magma than by a felspathic one, since in both felspars and felspathoids the ratio of Na, K : Al is the same. This particular conversion must be due to an excess of alkali in the magma, of which no trace remains as such when the rock has solidified and become exposed to investigation. With this point, however, I am not at present concerned. There remains the theoretical possibility that aluminium silicates might be reduced to corundum by reaction with an undersaturated magma.

4. When the invaded rock is a carbonate or other non-silicate rock, or contains much lime, magnesia, or iron in the form of oxide or carbonate, then the advantage as regards absorbing power lies with the saturated and oversaturated magmas, which can yield first their excess of silica, and secondly a further quantity of silica due to the reduction of sodium, potassium, calcium, and magnesium molecules from the saturated to the unsaturated state. In this way a saturated or oversaturated magma may become undersaturated. This case, as regards alkaline rocks, has been presented by R. A. Daly.[1]

The above deductions involve no assumption at all as to the *extent* to which absorption takes place in nature; so long as even a few instances arise in which absorption is admitted to have taken place, then it becomes necessary to recognize the essential difference in the absorptive capacity of saturated and undersaturated magmas. The appearance of, let us say, nephelite in a syenitic rock means far more than the mere addition of another name to the list of accessory minerals present in the rock; it involves a real difference, both of kind and degree, in the reaction of the magma towards its environment. By studying the distribution of the saturated and undersaturated members of an igneous complex one may gain a wider view of the process of differentiation than is to be had from the study of minute mineral and chemical differences alone.

With these considerations in view, it is instructive to turn to the distribution of oversaturated and undersaturated rocks in the lithosphere.

1. As regards mere bulk, the oversaturated and saturated rocks predominate enormously over the undersaturated. Daly[1] estimates

[1] "Origin of the Alkaline Rocks": Bull. Geol. Soc. Amer., 1910.

that "all the visible alkaline rock of the world probably constitutes less than 1 per cent of the total visible igneous rock". If in addition to the alkaline rocks we consider the olivine, melilite, melanite, and corundum-bearing rocks, it seems likely that the total mass of the undersaturated rocks will scarcely exceed 2 per cent of the total visible igneous rock.

2. Among major intrusions the vast majority consists of over-saturated rocks. Saturated rocks have a much smaller representation, and undersaturated rocks are relatively rare except as marginal facies and differentiated bodies. Where nephelite-syenites occur they are in surprisingly many cases associated with limestones, and Daly[1] makes out a good case for regarding some of them, at all events, as due to absorption of limestone. Thoroughly unsaturated types (e.g. dunite) never form truly major intrusions.

3. Among lavas and minor intrusions the oversaturated types are quite subordinate to the saturated and undersaturated. Thoroughly unsaturated types, though rare, are recognized in dunites and some monchiquites and alnöites. Undersaturated types, such as nephelite and leucite tephrites, basanites, and basalts, olivine dolerites and basalts, picrites, peridotites, and serpentines, are well represented.

4. A curious point, which will, I think, survive the test of statistics, is the very frequent occurrence of undersaturated and unsaturated rocks in the pipes of single-explosion volcanoes. The olivine bombs of the Dreiser Weiher and other volcanoes of the Eifel and Auvergne, and the ultrabasic agglomerate with content of olivine and pyrope which fills the pipes of some of the volcanic necks of Scotland, will serve to illustrate this point, but the most superb examples are the kimberlite and alnöite pipes of South Africa. Kimberlite, with its abundant olivine and pyrope, and its possible melilite,[2] is emphatically undersaturated; while some of the alnöites, as described by Rogers,[3] are entirely unsaturated.

These observations can be reduced to the following form: Those igneous rocks which have been brought up most rapidly from the earth's interior, and have solidified most rapidly in or on the crust, are to a marked extent undersaturated. Those others which have slowly worked their way up into the crust (and have hence had abundant opportunity for absorbing silica) are found to be predominantly oversaturated. We have here a strong suggestion that undersaturation may be characteristic of the deeper zones of the lithosphere, as oversaturation is of the higher. I do not wish to insist upon this point, but merely to show that the distinctions employed here have their uses even in the discussion of the major problems of geochemistry.

The conceptions of saturation and undersaturation are capable of application to the classification of igneous rocks, and provide just those natural distinctions between different types, the absence of which petrographers have been accustomed to deplore. If writers

[1] "Origin of the Alkaline Rocks": Bull. Geol. Soc. Amer., 1910.
[2] Carvill Lewis, 1897; Mennell, 1909.
[3] Trans. S.A. Phil. Soc., 1904; Ann. Rep. Geol. Comm. (Cape of Good Hope), 1911.

like Dr. Hatch[1] and Mr. Mennell,[2] who tie their faith to silica percentages, would instead employ the mineralogical dividing lines which separate the oversaturated from the saturated rocks, and these again from those which are undersaturated (1) with regard to leucocratic constituents, (2) with regard to melanocratic constituents, and from (3) those which are undersaturated or unsaturated in all their constituents, they would find themselves in possession of a much more 'natural' classification of rocks, and one which would be vastly simpler to use than any classification which is based upon silica percentages. The connexion between mineral and chemical composition need not be obscured thereby, but rather the reverse, especially if, as could easily be done, the relative degrees of oversaturation or undersaturation were introduced as subordinate factors in the classification. The fact that, under different conditions of temperature and pressure, one and the same magma may give rise to rocks of different degrees of saturation, is an argument in favour of my contention, not against it. The classical experiment of Fouqué and Michel-Lévy, in which a melt of orthoclase and biotite yielded leucite and olivine on cooling, illustrates this point. The silica percentage, being the same in the product as in the educt, fails to express the difference between these two very different mineral associations; yet the former is saturated, the latter unsaturated, and by making degree of saturation a criterion of systematic position we effect a separation of things formed under unlike conditions, which is at least as important as the separation of things of unlike ultimate composition.

If Dr. Hatch and Mr. Mennell had considered the natural criterion of undersaturation, in place of the artificial one of silica percentage, they would not have been led into the paradoxical positions of classifying borolanite, a rock which typically contains neither plagioclase nor augite, with "alkali-gabbro" and "dolerite" respectively. In my opinion both these gentlemen have erred by committing themselves to classifications which are neither definitely chemical nor definitely mineralogical. A chemical classification, to be of any value, must have regard to *all* the molecules present in a rock, not to one alone. If a classification is to be mineralogical, let it be consistently so. I believe that both chemical and mineralogical classifications are necessary, but of hybrid classifications I would go so far as to say, as Harker says of hybrid rocks, "like other hybrids, they are barren."

The recognition of the essential difference between saturated and undersaturated rocks ought to lead to the avoidance of such loosely-used terms as shonkinite, monzonite, and essexite. We read in Dr. Hatch's textbook, for example, that "nepheline and leucite occur occasionally in monzonites"; that essexites contain a variable quantity of nepheline; and that nepheline and sodalite "may be present in small quantities" in shonkinite. The older petrographers always drew a sharp distinction between the syenites and the nepheline-syenites; however small the proportion of nepheline, it was considered sufficient to justify the removal of the rock from the former to the

[1] *Textbook of Petrology*, 1909. [2] *Manual of Petrology*, 1913.

latter class. The same procedure, with regard to olivine, is followed to this day in the application of the names tephrite and basanite, nephelinite and nepheline basalt. The distinction between the saturated and the unsaturated minerals is a real one, with important consequences in the chemistry of rock magmas; and petrographers who shut their eyes to a natural distinction of this kind deserve the fate that awaits them at the hands of inventors of arbitrary classifications.

The present paper is an argument for the importance of the above distinction, and a plea for its recognition in petrographic nomenclature.

VI.—Septaria: a Defence of the 'Shrinkage' view.

By T. Crook, A.R.C.Sc. (Dublin), F.G.S.

A CONTRIBUTION to the March number of the Geological Magazine by Dr. A. M. Davies, and another in the August number by Mr. J. E. Todd, support a view formerly held by Professor H. G. Seeley, viz. that the cracks of septaria are due to expansion, during growth, of the outer layer of the nodule.

For several reasons this view appears to me to be untenable. It seems to be based on an erroneous conception of what takes place during the growth of a septarian nodule. It exaggerates the significance of crystallizing force in material deposited from solution. In a rudimentary way a nodule is a crystalline growth, but the manner of this growth speaks of a force of crystallization that has been thwarted and not allowed free play. A nodule is of the nature of an imperfectly crystalline precipitate, rather than a robust crystalline growth. It consists of a mass of shapeless microcrystalline granules, each of which was presumably deposited from solution in such a way as to accommodate itself quietly to the surface on which it grew. Surely Mr. Todd makes a mistake when he compares the crystallizing force of material deposited from solution to the expansive force manifested by water in solidifying. There is no analogy between the two processes.

I think we are justified in asserting that the growth of a septarian nodule in a clay has at least this in common with the growth of a crystal from solution: it presents a sharply defined surface to the medium in which it is growing, and it grows by addition of material to the surface. And if material can be deposited on the faces of a growing crystal without the interior being ruptured by the crystallizing force when that force displays its full vigour, why should the addition of shapeless and accommodating microcrystalline granules to the surface of a growing nodule result in internal rupture?

Moreover, nodules are septarian only when they have incorporated within their substance a considerable amount of colloidal clayey matter. If a nodule consists of fairly pure carbonate, or if it contains sandy matter to the exclusion of clay substance, it does not become septarian. How is this fact explained by the 'expansion' view?

Again, I fail to see how we can allow the last added shell of the nodule to crack the enclosed mass without cracking itself; and if the outer shell did expand during growth without cracking itself, the process would probably result in a series of concentric cracks infilled with calcite, rather than in radiating cracks. There is really no evidence that the cracks develop during growth in this way; and until some proof is forthcoming that crystallizing force acts in the way suggested, it seems more reasonable to adopt the view that the cracks arise from shrinkage subsequent to growth. This shrinkage view seems to be well in accordance with the facts, and accounts for the results in a more satisfactory manner.

In explaining the formation of the cracks by shrinkage, it is important to note that the rate of radial growth of a nodule probably diminishes very rapidly as the nodule increases in size. If we assume, for the sake of argument, that its shape is spherical, then the surface area of the growing nodule increases as the square of the radius. It follows, therefore, that the surface of deposition when the nodule is 10 cm. in diameter is 10,000 times greater than it was when the diameter was 1 mm., and 100 times greater than it was when the nodule had a diameter of 1 cm.

Not only is there this tremendous rate of increase in the surface of deposition during the growth of the nodules: there is also a decrease in the dissolving surface; for the particles of less stable carbonate from which the solution maintains its supply are continually diminishing in size as the nodules grow. Until the contrary is proved, it is reasonable to infer from these facts that the rate of radial growth diminishes enormously as the nodule increases in size. If so, its substance during growth will gradually increase in compactness from the centre outward; and the last-formed layers will probably be very much more compact than the first-formed layers.

We should expect that the first-formed part of a nodule would incorporate more argillaceous material than the portions formed later. Mr. Todd states that this is not the case; but his statement is not convincing. At least we may assume that the argillaceous material of the earlier-formed portion is much wetter than that of the later-formed portion of the nodule.

We may still conclude, therefore, that the internal mass of the nodule consists of wet argillaceous carbonate, and that it is surrounded by an outer shell of drier and more compact material. The nodule in this state will, like the enclosing sediment, continue to suffer from the compacting process. It will lose water, and shrink. The more compact outer shell will suffer little tangential contraction. The contraction of the wetter interior will be more considerable, and will be accommodated by a shrinkage of the mass on the outer shell. This will result in the development of radiating cracks, which may ultimately become filled with calcite.

I see nothing in the facts so far adduced that invalidates this explanation. It is singular that so little has been done in the way of investigating the facts bearing on this subject, and that so much has been left to speculation. Until a fuller investigation has strengthened the case against it, I for one shall continue to hold the 'shrinkage' view.

NOTICES OF MEMOIRS.

Abstracts of Papers read in Section C (Geology), Meeting of British Association, Birmingham, September 10–17, 1913.

1. On various Occurrences of Pillow Lavas in North and South Wales. By A. Hubert Cox, M.Sc., Ph.D., F.G.S., and Professor O. T. Jones, M.A., D.Sc., F.G.S.

Pillow lavas were described from four localities, viz.:—

(*a*) Strumble Head, in Pembrokeshire.
(*b*) Cader Idris, in Merionethshire.
(*c*) Sarn Mellteyrn, near Pwllheli, Carnarvonshire.
(*d*) Careg, 2 miles N.N.W. of Aberdaron, Carnarvonshire.

(*a*) Strumble Head (A. H. Cox).—References were made particularly to the work of Reed and Elsden. The rocks were formerly regarded as intrusive, and were described as of composite characters and possibly of later date than the main folding.

Variolitic rocks were described by Reed, who referred to the 'pillow structure' as 'spheroidal jointing'. The whole mass appears to consist largely of highly vesicular, basic flows, some with well-developed pillow structure, others showing transitions to non-pillowy types. Abundant chert occurs in association with the lavas, particularly those showing pronounced pillow structure. The most perfect pillows vary from a foot to 18 inches in diameter, and consist of typical spilites, with thin, rod-like felspars of refractive index about 1·542, corresponding to oligoclase—the rocks are considerably decomposed, especially to calcite, chlorite, and epidote.

Among the above rocks are ophitic diabases, showing marked columnar jointing, which may in part represent sills.

(*b*) Cader Idris (A. H. Cox).—A thick band of pillow lavas forms the highest point of the Cader Idris range, and then strikes W.S.W. Its distribution is described in detail, and reference is made to the work of Ramsay and Geikie. A comparison of these rocks with those of Strumble Head discloses certain differences, especially in their uniformly less vesicular character and smaller amount of associated chert. Under the microscope the rock shows the character of a typical spilite; both rod- and lath-shaped felspars occur, the former being oligoclase, the latter somewhat richer in soda (refractive index below 1·541). The rock is considered to resemble most closely that of Mullion Island. In close association with it is the 'Eurite' (soda-granophyre) of Cole and Jennings. These lavas appear to occupy a stratigraphically higher horizon than the beds which yielded *Didymograptus bifidus* and *D. murchisoni* to Lake and Reynolds. The detailed examination of the area is still incomplete.

(*c*) Sarn Mellteyrn (O. T. Jones).—References were made to the work of various authors, viz. Ramsay, Harker, Raisin, Elsden, Matley.

The rocks are exposed by the roadside three-eighths of a mile south-west of Mellteyrn Church, where 10 to 12 feet of typical pillow lavas overlain by a similar thickness mainly of non-pillowy rocks of allied characters are followed by flinty mudstones and micaceous shales.

The spaces between the pillows are occupied by closely-jointed dark-grey chert. The sediments dip to the east at a moderate angle, and probably pertain to the lower part of the Arenig. The pillow lava is finely vesicular and considerably decomposed; the felspar is oligoclase and forms lath-shaped microliths. From its structure and mineralogical character the rock is referred to the spilitic suite.

(*d*) Careg, near Aberdaron (O. T. Jones).—These rocks have been described in detail by Raisin, and the pillow structure noted as 'spheroidal structure'. The present notes are intended to supplement that description in certain respects.

The pillow structure is seen near Careg quarries and near the coast; individual pillows have a length of about 2 feet, and are composed of a fine-grained rock with small vesicles. The felspars have the extinction-angle and refractive index of oligoclase-albite, and are highly charged with decomposition products. These rocks are undoubted spilites, and were claimed as such by Dewey and Flett; they are associated with 'limestones' of a peculiar character, together with beds and strings of jasper, which in places wrap round the pillows in the same manner as the chert near Sarn. The association of that rock with a pillow lava may perhaps be regarded as confirming Greenly's suggestion that the jaspers of Anglesey were originally cherts. The associated rocks at Careg have an extraordinarily complicated structure, and probably belong to the pre-Cambrian.

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2. Critical Sections of the Cambrian Area called the Cwms in the Caradoc–Comley Region of Shropshire. By E. S. Cobbold, F.G.S.

THE work of excavation of critical sections in the Cambrian rocks of Shropshire has been continued by the writer at intervals during the past year, and has furnished palæontological proofs of the prolongation of the Lower and Middle Cambrian rocks of Comley into the Cwms area to the south. The sections opened up confirm and amplify those excavated in previous years.

Excavation No. 53 supplies details of the upper portion of the Wrekin Quartzite and the lowest part of the Lower Comley Sandstone, near the base of which three fossiliferous bands are found, yielding species provisionally referred to *Kutorgina*, *Hyolithus*, *Hyolithellus*, and *Archæocyathus*.

Excavation No. 54 exhibits a section of the junction of the Middle and Lower Cambrian beds, which is very closely comparable with those of the Quarry Ridge at Comley.

The beds in descending order are as follows:—

		ft.
e.	Shale with Grit Bands = The Quarry Ridge Shale, top not seen	4
d.	Hard, ringing, glauconitic Grit = The Quarry Ridge Grit .	28
c.	Conglomerate = The Quarry Ridge Grit, conglomeratic portion	9
b.	Dark Grey, Purplish, and Red Limestones = The Black, Grey, and *Olenellus* Limestones of Comley	about 4
a.	Green, Micaceous Sandstones, with spotted bands = The Lower Comley Sandstone; base not seen	10

The conglomerate *c* is plentifully charged with fragments of the Black and other Lower Cambrian Limestones, and it is now proved for the first time that the Black Limestone must be grouped with the Lower Cambrian.

The surface of the solid Black Limestone is coated with a phosphatic (?) skin, and a similar deposit in the Comley Quarry has within the last two or three years yielded recognizable fragments of *Paradoxides* sp. and *Dorypyge Lakei*, Cobbold. The black skin must, therefore, be regarded as the lowest deposit of the Middle Cambrian age that is known in the district.

Among the numerous fossil fragments that occur in the Lower Cambrian Limestones of this excavation the following have been identified: *Anomocare* (?) *pustulatum*, Cobbold, *Callavia Callavei*, Lapworth (?), *Microdiscus Attleborensis*, S. & F., sp., *Protolenus* sp., *Kutorgina* sp., *Linnarssonia* (?) sp.

Excavation No. 55 exhibits a faulted junction between the Middle and Lower Cambrian, the hard, ringing Grit (beds *d* above) being brought into contact with the Green, Micaceous Sandstone (beds *a* above).

Excavation No. 56 proved the existence of both the Quartzite and the lower part of the Lower Comley Sandstone at another point in the area.

A section constructed embodying the results of these excavations provides evidence that the Lower Comley Sandstone has a thickness of about 480 feet.

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3. *Estheria* in the Bunter of South Staffordshire.[1] By T. C. Cantrill, B.Sc., F.G.S.

Records of fossils in the British Bunter are few in number, and some are open to doubt in respect either of their organic character or of the stratigraphical position of the beds that yielded them. Omitting those cases where the horizon formerly supposed to be Bunter has been corrected later and is now accepted as settled, the following appears to be a complete list, in chronological order of their discovery:—

1. *Dictyopyge catoptera* (Ag.), a small fish, from Rhone Hill, 3 miles south-east of Dungannon, co. Tyrone. Upper Bunter (f^3). With this was associated *Estheria portlocki*.

2. 'Annelid tracks' at Hilbre Point, Wirral, Cheshire. Lower part of the Bunter Pebble Bed (f^2).

3. Plant-remains, referred to *Schizoneura paradoxa*, Schimper and Mougeot, at Sneinton Vale, near Nottingham. Uppermost bed of the Bunter Pebble Bed (f^2).

To these three older records can now be added the following new discovery[1]:—

4. *Estheria* cf. *minuta* (Alberti), from Ogley Hay, near Walsall, South Staffordshire. Bunter Pebble Bed (f^2).

[1] Communicated by permission of the Director of the Geological Survey.

These fossils were discovered in May, 1911, when Mr. C. H. Cunnington and I were mapping the Triassic rocks bordering the eastern side of the coal-field. I suggested to my colleague that if fossils could be found anywhere in the Bunter they would most likely be discovered in the thin marl-bands occasionally interbedded in the predominant sandstones and conglomerates; and Mr. Cunnington's hammer was the first to reveal the specimens.

We obtained them from two thin bands of red marl in a disused sand-quarry at Ogley Hay, 5 miles north-east of Walsall. The quarry forms a conspicuous excavation in the northern face of a sandstone hill, along the foot of which passes the Anglesey branch of the Wyrley and Essington Canal. The hamlet of New Town, on the Watling Street, lies 150 yards to the north of the quarry, while Ogley Hay Chemical Works stands 200 yards away to the south-east. Below a little drift gravel are exposed 22 feet of dull-red medium-grained soft sand-rock, in places false-bedded. Toward the bottom are two bands of red marl, about 1 ft. 8 in. apart, the lower one being about 2 feet above the bottom. They nowhere exceed 9 inches in thickness. Both marl-bands yielded poorly preserved remains, determined by Mr. H. A. Allen as *Estheria* cf. *minuta* (Alberti).

The ground is coloured on the old series 1 inch map (62 N.E.) as Upper Bunter (f^3); but the sandstones are coarser and duller in colour than the typical Upper Bunter of other Midland districts, and would more suitably be included in the outcrop of the Pebble Beds (f^2). The Triassic series dips at 3° to 5° toward E.N.E., in which direction the Pebble Bed subdivision appears to pass laterally into, and partly beneath, finer-grained and brighter-coloured sandstones that may be regarded as Upper Bunter. Above these follows the Lower Keuper Sandstone (f^5). There is thus no question as to the beds in the quarry being Bunter, and every ground for referring them to the Pebble Bed subdivision.

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4. The Relation of the Rhiwlas and Bala Limestones at Bala, N. Wales. By Dr. Gertrude L. Elles.

THE difficulties in the interpretation of the succession in the Bala district appear to be due largely to the impersistent nature of the limestones and their inconstancy as to horizon.

The succession is as follows:—

Hirnant Series	Hirnant Limestone (impersistent).
	Hirnant Flags and Mudstones.
	Rhiwlas Limestone (impersistent).
Bala Limestone Series	Bala Limestone (impersistent).
	Calcareous Ash.
	Mudstones.
	Coarse Ash.
	Mudstones and flags with thin impersistent Limestones.
	Ash.
	Sandy flags, with occasional impersistent Limestones.
	Ash.
	Sandy flags becoming shaly towards base.

The Rhiwlas Limestone is an impersistent limestone at the base of the Hirnant Series, and is found only in the northern part of the area. The Bala Limestone is not developed as a calcareous bed in the northern part of the area, but is somewhat more persistent as a definite band in the southern and eastern portions of the district. The true relations of these horizons to each other is seen in the type section at Gelli Grin, where the Bala Limestone at its maximum thickness is overlain by light-coloured, pasty mudstones containing a typical Rhiwlas Limestone fauna. The fauna is not nearly so rich in individuals as that of the Rhiwlas Limestone itself, but all the more important genera and species seem to be represented. Confirmatory sections are also seen east of the fault near Gelli Grin Farm, and also on Bryn Cut.

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5. The Shelly and Graptolitic Faunas of the British Ordovician. By Dr. Gertrude L. Elles.

THERE are two main types of 'shelly' faunas of Ordovician age in the British Isles, and each of these can be further subdivided into a number of sub-faunas which can be correlated by reference to associated graptolite-bearing beds.

Ordovician Faunas.

<table>
<tr><th>Graptolitic</th><th colspan="2">Shelly</th></tr>
<tr><th>Graptolite Zones</th><th>A</th><th>B</th></tr>
<tr><td>Zone of Cephalog. acuminatus</td><td rowspan="2">Staurocephalus fauna</td><td rowspan="2">Staurocephalus fauna
Exotic fauna . 4</td></tr>
<tr><td>Zone of Dicellog. anceps</td></tr>
<tr><td>Zone of Dicellog. complanatus</td><td rowspan="4">Calymene planimarginata fauna with sub-faunas (a) Chasmops; (b) Asaphus Powisi
— — —?— — —</td><td rowspan="2">Exotic fauna . 3</td></tr>
<tr><td>Zone of Pleurog. linearis</td></tr>
<tr><td>Zone of Dicranog. clingani</td><td rowspan="2"></td></tr>
<tr><td>Zone of Climacog. Wilsoni</td></tr>
<tr><td>Zone of Climacog. peltifer</td><td rowspan="3">Ogygia Buchi fauna with Asaphus tyrannus sub-fauna</td><td>Exotic fauna . 2</td></tr>
<tr><td>Zone of Nemag. gracilis</td><td></td></tr>
<tr><td>Zone of Glyptog. teretiusculus</td><td>Exotic fauna . 1</td></tr>
<tr><td>Zone of Didymog. Murchisoni</td><td rowspan="2">Placoparia fauna</td><td rowspan="5"></td></tr>
<tr><td>Zone of Didymog. bifidus</td></tr>
<tr><td>Zone of Didymog. hirundo</td><td rowspan="3">Ogygia Selwyni fauna</td></tr>
<tr><td>Zone of Didymog. extensus</td></tr>
<tr><td>Zone of Dichograptus</td></tr>
</table>

The main shelly types may be described as—

A. Asaphid-Trinucleid-Calymenid fauna.
B. Cheirurid-Lichad-Encrinurid fauna.

Evidence suggests that fauna B is an exotic fauna, possibly southern in origin, which migrated into the British area. Becoming early established in South Scotland, it soon spread west into Ireland, but did not dominate the whole British area till Ashgillian times.

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6. THE BASAL CARBONIFEROUS BEDS AT LYE, IN SOUTH STAFFORDSHIRE. By W. WICKHAM KING, F.G.S., and W. J. LEWIS, B.Sc.

IN the GEOL. MAG., Dec. V, Vol. IX, p. 437, 1912, we announced (*inter alia*) that *purple* beds of Lower Old Red age existed at Saltwells. Since then we have ascertained that 2 miles to the south, at Lusbridge Brook, Lye, below the Thick Coal, Carboniferous beds are exposed for a thickness of nearly 400 feet as against about 200 feet at Saltwells. These basal beds are difficult to interpret.

The succession below the Thick Coal in Lusbridge Brook is thus: (*a*) Various Clays and Coals, 280 feet; (*b*) Conglomerate, 27 feet; (*c*) Red Clays (Plants) and White and Yellow Clays, in which are embedded many pieces of quite unworn Cherts, and at base Limestone Grits and a Conglomerate, thickness 40 feet; (*d*) White, Red, and Yellow Clays. (*d*) is only exposed for about 30 feet. Total below Thick Coal, 377 feet. Mr. F. G. Meachem has kindly given to us data proving that the beds down to the base of (*b*) are the same thickness in the Freehold Pit, Lye, and that there, below (*b*), they pierced Red Marls for 150 feet.

The interesting zones are those in which the Limestone Grit and Cherts occur. Broken fossils occur in the Limestone Grit, which is made up largely of angular pieces of Limestone. In the Conglomerate (*b*) a pebble 18 inches in diameter of highly calcareous grit containing *Calamites varians* has been found, which is probably another type of this Limestone Grit. A precisely similar calcareous grit was found in situ at or below (*b*) in the Freehold Pit, and above (*c*) a nearly similar type occurs in the form of gigantic slabs 2½ feet thick in the Lye Cemetery.

The Cherts contain many casts of fossils, but they are so imperfect that we hesitate to name them. We found in the clays (*c*) a minute fragment of a Brachiopod with a straight hinge-line.

Pebbles of (*inter alia*) Limestone Grit and Cherts occur in the Conglomerates.

The Limestone Grits, Cherts, and Clays at Lye are such as might be laid down in the vicinity of a shore-line and there disintegrated in situ. In several respects they resemble the Rush Conglomerates of Lower Carboniferous age in Ireland. Compare Q.J.G.S., vol. lxii, p. 285.

In the Conglomerates there is distinct evidence of Inter-Carboniferous denudation which removed in places, as at Saltwells, the Coal-measure Ironstone (*Neuropteris*), Coal Seams, Grey Limestones, Limestone Grits, and Cherts.

In Q.J.G.S., vol. lv, p. 123, 1899, Mr. King showed that all the pebbles in the Permian Conglomerates of the Severn Basin are referable to a local source, except only those of Lower Carboniferous age. The last-mentioned pebbles contain *Syringopora* and *Caninia*.

Some of the pebbles that he regarded as of Lower Carboniferous age are identical lithologically with the Limestone Grits and Cherts now found at Lye.

In Permian times the Lower Carboniferous Rocks provided, from original and derivative local sources, much of the material in the Permian Calcareous Conglomerates.

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7. The Development of the Midland Coal-fields. By Fred. G. Meachem, M.E., F.G.S.

GREAT advances have been made in mining since the first meeting of this Association in Birmingham in the year 1839. Women were then employed in the mines, also children under 10 years of age, and all worked twelve hours or more in the pit. To-day women are not allowed to work in a mine, and no youth under 14 years, and the hours of labour are restricted by Act of Parliament to eight per day. Nearly all the mines worked in 1836 were shallow ones, and the output not more than 200 to 300 tons per week. The area of the coal-fields was about as shown below, as against the present known and concealed areas of coal.

Year.	South Staffs.	Leicester.	Warwick.	Salop.	Total square miles.
1836 . .	70	20	10	20	120
1913 . .	360	88	222	96	766

This last calculation includes the concealed coal-field between Chasetown, Aldridge, and West Bromwich on the west and the Warwickshire and Leicestershire Coal-fields on the east, and also the concealed coal-field between Cannock, Essington, and Stourbridge on the east of the Coalbrookdale and Forest of Wyre Coal-fields on the west.

The output since figures are available is as follows:—

Year.	South Staffs.	Leicester.	Warwick.	Salop.	Total in million tons.
1865 . .	10	$1\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{2}$	$13\frac{3}{4}$
1912 . .	$7\frac{1}{2}$	$2\frac{3}{4}$	$4\frac{1}{2}$	$\frac{3}{4}$	$15\frac{1}{2}$

This shows a great advance in industrial conditions and in Economic Geology, but the question of output does not show so great an increase; this I think is due, not to fear that the concealed coal-fields would not be profitable, but to the fact that some of the deeper mines have not proved remunerative. This is partly due to local conditions in the mines and also to the fact that the deeper coal costs more to get than the shallow coal, as regards actual working cost and the greatly increased capital needed, whilst the coal from both mines is sold in the same market, so that the shallow mine rules the selling price. As a few years pass by, and probably before the next meeting of this Association, the shallow mines will be exhausted, and the prices will be ruled by the deeper mines, with the usual economic results of increased prices in proportion to increased costs to get.

In the figures above, areas are included which were not thought of in 1836, but, as is fully shown by the report of the last Royal Coal Commission, 1905, coal will undoubtedly be found in the areas above named. The area between the South Staffordshire Coal-field and the Leicestershire and Warwickshire Coal-field will be found to be one continuous coal-field, with its deepest part at Lichfield, Sutton Coldfield, and Coleshill, but the basin rising to the south as a whole, the thick coal of Sandwell and Hamstead will split up into two or three seams, and under these conditions will be worked Longwall, with better commercial results. The area between the Staffordshire Coal-field and Shropshire has been most vigorously investigated, and the proofs at Colwich, Huntingdon, Essington, Four Ashes, and Baggerridge show that this area is going to be rich in coals of good quality and laid down under conditions that will allow of remunerative working.

On the Shropshire side very little has been done to extend that coal-field to the west of either the Coalbrookdale or the Forest of Wyre Coal-fields; the edges of the Old Red Sandstone preclude any hope of extension, but in the Highley and Kinlet and Billingsley area it is most probable that future deeper sinkings will prove deeper coals than the two seams at present working, whilst the area to the east is full of promise. As soon as the Severn Valley Fault, which is some 300 to 400 yards downthrow east, is crossed, a new coal-field will be found, and I think the area between here and the old coal-field will be divided into two basins, with a Silurian anticline between them as proved by the Claverley boring.

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8. On the occurrence of a Wind-worn Rock-surface at Lilleshall Hill, Salop, and of Wind-worn Stones there and elsewhere. By Frank Raw, B.Sc., F.G.S.

LILLESHALL HILL, lying some 5½ miles north-east of Wellington, and extending north-east and south-west, is a 'hogsback' of Uriconian, and is largely bare rock. The exposed rock of its south-east side consists towards the north-east of very hard hälleflintas, interstratified with somewhat softer tuff, and to the south-west of this and opposite the Monument of still harder felsite conglomerate and grit.

Practically the whole of this rock-surface has been ground smooth and, where hardest, has been highly polished, the smooth surface being traceable everywhere except where it has obviously been removed by weathering or quarrying. The surfaces of projecting masses of the conglomerate are perfectly fresh, being ground smooth, deeply fluted, and polished as by wind-blown sand, the radiating flutings showing the paths of escape of the prevalent wind. To the north-east the rock-surfaces have been much more even, perhaps based on a previously glaciated surface, and the flutings are parallel and in that direction less and less highly inclined, till at the north-east end they lie at an inclination of 15° to 20° up to the north in north and south planes.

From the south-west end of the wind-worn surfaces already described similar polishing can be traced across the hill to the north-west on the steep rock-surfaces of quartz-veined hälleflintas which bound on the south-west the highest part of the hill.

South-west of this the crest of the hill is fairly flat and covered with grass. Here two reservoirs have been constructed for the

Lilleshall water supply, and several of the stones thrown out were found to be beautifully wind-worn and polished. Two trial excavations made near by yielded a considerable proportion of wind-worn stones embedded in fine soft red sand.

In one of the excavations carried to a depth of 29 inches there also occurred immediately beneath the turf a definite layer of white even-sized wind-worn sand, the grains measuring about $\frac{1}{30}$ inch in diameter, above the fine red sand with wind-worn stones.

The occurrence of wind-worn stones is also recorded from other localities in the Midlands, and specimens in illustration are exhibited.

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9. Plant Petrifactions in Chert and their bearing on the Origin of Freshwater Cherts. By Marie C. Stopes, D.Sc., Ph.D.

THE author described, and illustrated with photos, petrifactions of plants in the freshwater cherts of Lulworth (Purbeck) and Asia Minor (Tertiary). The author drew special attention to the Asia Minor cherts, which are remarkably interesting and contain well-preserved plant debris. These were described by Mr. Haydon in his presidential address to the Liverpool Biological Society, but his work seems not to have reached most geologists and palæobotanists. The cherts contain beautifully preserved pollen grains, fungi, stem debris, etc.; and the existence of these delicate soft tissues so well preserved suggests that Sollas's view of flint formation can only be applied with caution to these freshwater cherts.

The author drew attention to the recent 'Sapropel' observed by Potonié, and the likeness it has to the debris in the Asia Minor chert; concluding that the chert may be taken as practically pure petrified 'Sapropel', a phenomenon which must interest those who are concerned with the methods of plant petrifactions.

REVIEWS.

I.—Geological Survey of a part of South Devon.

The Geology of the Country around Newton Abbot. By W. A. E. Ussher, F.G.S.; with contributions by Clement Reid, F.R.S., J. S. Flett, D.Sc., F.R.S., and D. A. MacAlister, A.R.S.M. 8vo; pp. vi, 148, with 3 plates and 14 text-illustrations. London: printed for H.M. Stationery Office, 1913. Price 3*s*.

THE country described in this memoir is a highly interesting and picturesque portion of South Devon, wherein are to be seen the fossiliferous Devonian limestones of Bradley Woods and elsewhere near Newton Abbot, and other Devonian strata with interbedded and intrusive igneous rocks; the Culm Measures with chert-beds and fossiliferous shales at Waddon Barton, near Chudleigh, and intercalated igneous rocks to the west, including portions of the Dartmoor granite at Lustleigh. Then the coast is dominated by fine cliffs of Red Rocks, ranging in upward succession from the Permian terra-cotta clay of Watcombe through the bold masses of conglomerate and breccia, sandstone and marl which extend to Teignmouth, Dawlish, and Exmouth. Beyond is the famous Bunter pebble-bed of Budleigh

Salterton, with overlying Bunter and Keuper Sandstones. Attractive also are the fossiliferous Upper Greensand outliers of the Haldon Hills, with their coverings of gravel grouped as Eocene; likewise the thick and varied deposits of the Bovey Basin, including the plant-bearing lignites and the pottery clays (now regarded as Upper Oligocene), and the overlying gravels and alluvial deposits, some undoubtedly Pleistocene, others of Holocene or Recent age. This great series of formations is well shown on the new colour-printed map, Sheet 339 (price 1*s.* 6*d.*), but the Pleistocene gravels have not been indicated in the Bovey Basin. The area in fact, as stated by the Director, Dr. Teall, in his preface, was to a large extent re-surveyed in 1874 and subsequent years on the old 1 inch map, particularly as regards the Permian and newer strata. This work was transferred to the new series map and published in hand-coloured form in 1899, considerable revisions having been made in the Palæozoic areas by Mr. Ussher. Still later revisions are included in the colour-printed edition of the map, and the mineral lodes have been inserted by Mr. D. A. MacAlister. The coloured section at the foot of the map is taken (perhaps wisely) to the north of the Bovey Basin, from the granite near Hennock, through Chudleigh, across Great and Little Haldon, and over the Red Rocks to Exmouth and East Budleigh.

An area containing so much of interest has naturally attracted many geologists, and among the early workers Godwin-Austen (then Austen) was conspicuous. Residing for a few years (from about 1831) at Ogwell House, near Newton Abbot, he prepared a geological map of the country, published in an elaborate and philosophical memoir in 1842 by the Geological Society; but the results of his field-work were given by Austen to De la Beche, who utilized them in the original Geological Survey map, Sheet 22, which was published in 1834. Of other workers H. B. Holl, and subsequently Arthur Champernowne, devoted much time to geological mapping, while J. E. Lee, G. F. Whidborne, Dr. Henry Woodward, Dr. G. J. Hinde, and Mr. Howard Fox added much to the knowledge of the palæontology of the older formations. It is remarkable, however, considering the careful account given of the literature, and the list of published papers, that no mention is made of the "Notes on Parts of South Devon and Cornwall" by J. B. Jukes (Roy. Geol. Soc. Ireland, 1868). In that paper Jukes records a meeting with Dr. Holl in a quarry near Newton Abbot, when he "laughingly remarked to him that 'one might toss up whether the beds were vertical or horizontal', for there were planes of division in both directions, either of which might be planes of stratification and the other joints".

To Mr. Ussher, who commenced work in the area in 1874, we are indebted for the elucidation of the main structure of the area, as regards not only the Devonian and Carboniferous, but also the Permian and Trias. His main conclusions on the older rocks were given in a paper published by the Geological Society in 1890. He now amplifies the information and gives details of the Devonian and Carboniferous subdivisions. It is observed that "as a whole the impersistence of the Devonian limestone is clearly proved, but direct evidence is wanting as to the original extension of the limestone in individual districts". While mostly of Middle Devonian age, certain parts of the limestone "may represent the Cuboides-stage of the Continental Upper Devonian". The higher portion of the Upper Devonian is represented by the *Goniatites-intumescens*-stage at Lower Dunscombe. The names of the Devonian fossils collected during the course of the survey have been revised by Dr. Ivor Thomas.

It is noted that in the Lower Culm Measures the chert-beds seem to be developed on different horizons, "immediately beneath the *Posidonomya*-beds and perhaps to some extent intercalated with them," and at lower positions down to the local base of the series.

The interbedded and intrusive igneous rocks of the Devonian and Carboniferous are described by Dr. Flett, who calls attention to the occurrence of spilites showing excellent 'pillow-structure' near Bickington. Schalsteins and quartz-keratophyres are likewise described. The intrusive rocks include diabases, proterobases, picrite, and portions of the Dartmoor granite, with felsites. Accounts are given of the contact alteration produced by the diabase sills, and of the metamorphic aureole bordering the granite.

The Permian rocks, including the basalt of Dunchideock, and the Trias are described by Mr. Ussher, and the Upper Cretaceous by Mr. Reid, who has naturally relied on Mr. Jukes-Browne for most of the particulars.[1] In transcribing "his account with a few modifications", it would have been well to have used inverted commas for the quotations, and to have inserted the modifications within brackets. The Eocene and Oligocene deposits are described by Mr. Reid, who gives his reasons for separating the Eocene, and presumably Bagshot, gravels of Haldon from the similar gravels at a lower level in the Bovey Basin. Much has yet to be done in following the connecting links between the Bagshot gravels of Black Down near Portesham in Dorset and the South Devon deposits. Details are given of the Bovey Beds, with list of plants, the majority of which have been determined by Mr. and Mrs. Reid to be "identical with species found in the well-known brown-coal deposits of Germany. These are now generally accepted as the highest Oligocene strata, though certain authorities class the Aquitanian stage as lowest Miocene".

The remaining portions of the memoir contain accounts of caverns and fissures, river gravels and head, recent changes, water supply, metalliferous deposits, building-stones, clays, lignites, etc. There is one plate of photomicrographs of igneous rocks, and another showing much-weathered Triassic sandstone resting on the Budleigh Salterton Pebble-bed.

II.—Geology and Forestry.

DURING the past few years the subject of afforestation has attracted more and more attention, and considerable areas of gathering ground connected with waterworks, as well as some tracts rendered barren and unsightly by tips from mines and quarries or by

[1] Memoir on Cretaceous Rocks of Britain, vol. i, 1900.

furnace refuse, have been successfully planted. Larger schemes for woodlands, more directly intended for economic purposes, are under consideration, and as their success depends fundamentally on geological considerations, on soil and substrata, on ground-water and drainage, which affect available plant-food, it is well that geologists should give some attention to the subject. We are glad, therefore, to see an article on "The Use of Geology to the Forester" (Trans. Foresters and Gardeners Society of Argyll for 1912, 1913), by Dr. C. B. Crampton, of the Geological Survey of Scotland. He emphasizes the need of giving attention to the horizontal and vertical distribution of the various rocks and soils, and their relations to the physical features. The formation of soils and subsoils on different types of rock is briefly explained; descriptions are given of screes, landslips, rain-wash, pan, etc.; and there are notes of trees and shrubs suitable for certain situations, having regard to geological, physiographical, and climatic conditions.

Special reference is made to the Scottish Highlands and to the effects of glaciation, whereby old soils were removed and large tracts rendered infertile, the results being summed up as "a baring of glaciated unweathered rock surfaces at all levels—a smothering of wide areas by sterilised and more or less impermeable boulder clay, and the piling up of loose glacial debris and leached sands and gravels". Extensive areas of this transported material, however, are under cultivation by the agriculturist, but as a rule they would not be suitable for plantations without the benefit of tillage.

While some of the Geological Survey maps, especiully those of the old hand-coloured editions, "form but a framework so far as the needs of the forester are concerned, since they give little indication of the presence or nature of subsoils and soils," it should have been added by the author that for South Wales and for many Midland and Southern counties of England, there are a number of published and many more MS., six-inch geological maps (copies of which can be purchased) that show in detail the superficial deposits. Moreover, even the published one-inch drift maps have been found by Mr. A. D. Hall and Dr. E. J. Russell to be of essential service in their important soil researches; and such maps are now issued by the Geological Survey of Scotland.[1]

III.—Annual Report of the British Museum for 1912. Pp. 212. H.M. Stationery Office, 1913. Price 10½*d.* net.

THE annual return, which made its customarily tardy appearance at the end of the summer, some seven months after the close of the year to which it refers, contains beneath a forbiddingly statistical air a great deal of interest, and is eloquent testimony to the important work being done by the expert staff at both branches of this great institution. Considerably more than half the number of pages are taken up with the Natural History Museum, and it is with these that we are mainly concerned here. We are glad to note a recovery from the great drop in the number of visitors reported in the previous year, though the numbers still remain some way below

[1] See Geol. Mag., 1911, p. 377.

those chronicled for 1910, and it is encouraging to notice a steady increase in the number of visits paid for purposes of study. The appointment of an official Guide to take members of the public round various parts of the museum daily, free of charge, has been much appreciated, and evidently meets a widely felt want. It is to be hoped, too, that the example of the parent institution in putting on sale picture postcards or other reproductions of objects of interest in the museum will be followed at South Kensington; such means of drawing attention to the museum and therefore of increasing its usefulness are not to be disdained. The rapid growth of the entomological collections and the importance of insects in relation to the spread of disease in man and in animals have led to the separation of the Entomological Section from the Zoological Department, and Mr. C. J. Gahan, formerly senior assistant, has been made the first Keeper of Entomology. So great is the congestion in the collections on this side of the museum that an extension of the building westward is under consideration. Dr. Jehu gave his fourth course of Swiney lectures in December and January, his subject being "The Record of Life as revealed in the Rocks". His appointment has been extended for another year, and he proposes to give a course of lectures in December on "The Natural History of Minerals and Rocks".

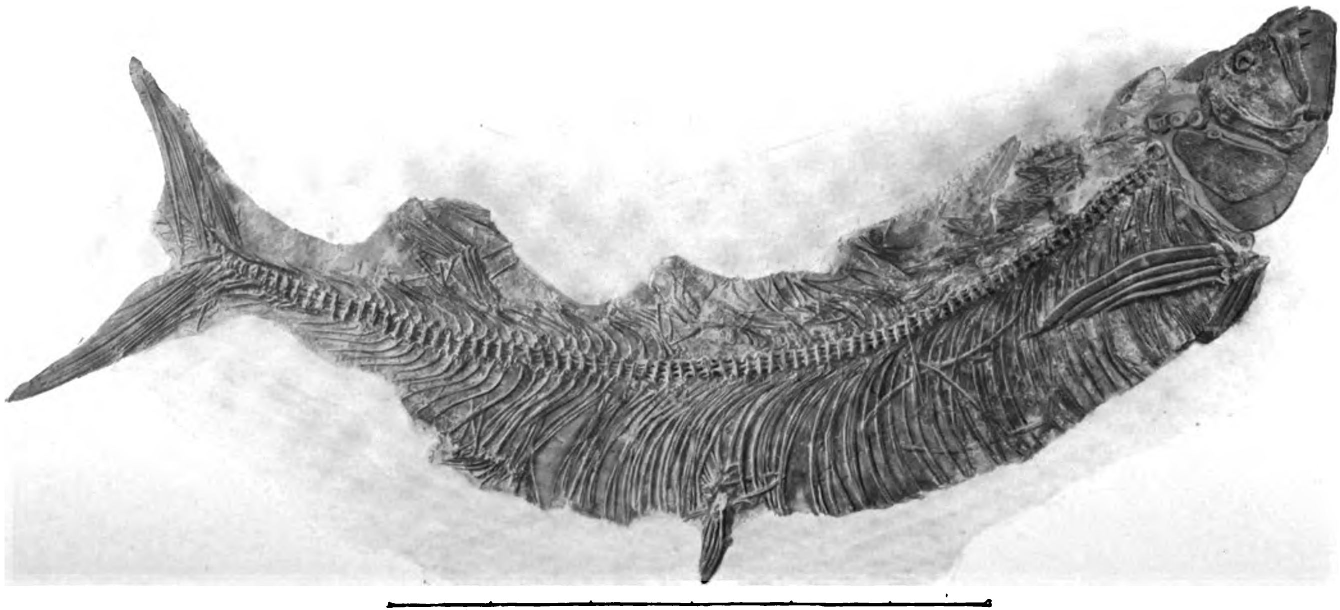
IV.—United States Geological Survey.—Water-supply Paper No. 292 (1913) continues the account of the surface water-supply, as part xii, North Pacific Coast. In No. 314 (1913) the "Surface Water-Supply of Seward Peninsula, Alaska" is described by Messrs. F. F. Henshaw and G. L. Parker, and included in the report are a sketch of the geography and geology by Mr. Philip S. Smith, and a description of the methods of placer mining by Mr. Alfred H. Brooks. The subjects are well illustrated by a geological map; a topographical map, on which are marked the gauging and rainfall stations and the placer deposits; and numerous pictorial views of flumes and other artificial water channels, and of mining operations and sluicing. In Water-supply Paper No. 317 (1913) Mr. C. H. Gordon reports on the "Geology and Underground Waters of the Wichita Region, north-central Texas".

MISCELLANEOUS.

At a meeting of Council in September, 1913, Dr. F. H. Hatch, M. Inst. C.E., F.G.S., etc., was duly elected President of the Institution of Mining and Metallurgy for 1914.

Dr. T. F. Sibly, F.G.S., Lecturer in Geology in King's College, London, has been appointed Professor of Geology in University College, Cardiff.

Mr. T. Sheppard, F.G.S., Curator of the Municipal Museums, Hull, has been elected President of the Yorkshire Naturalists' Union for the ensuing year. He had already filled the office of Honorary Secretary to that body for several years past with great success.



Portheus molossus, Cope. Chalk: Kansas. Reduced to $\frac{1}{24}$ nat. size; original nearly 14 feet in length. Exhibited in the British Museum (Nat. Hist.).

The black line under the specimen represents 6 feet in length.

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ORIGINAL ARTICLES.

I.—On a New Specimen of the Cretaceous Fish *Portheus molossus*, Cope.

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XVIII.)

SEVERAL nearly complete skeletons of the primitive teleostean fish *Portheus molossus* are now known from the Chalk of Kansas[1]; but none is better preserved than a remarkable trunk, nearly 12 feet in total length, lately obtained for the British Museum by Mr. Charles H. Sternberg. The specimen is shown, of about $\frac{1}{24}$ of the natural size, in the accompanying Plate XVIII, where it is seen mounted with the head of another fish of the same proportions. All the bones remain embedded in the matrix exactly as they were found, and there is no restoration beyond slight repairs.

The vertebral centra in the fossil form a continuous undisturbed chain from the pectoral arch backwards, only damaged a little by crushing. The total number of dorsal vertebræ is about fifty-five, while that of the caudals is thirty-three. From the pectoral arch backwards to the caudal fin all the centra are impressed on the side by two deep longitudinal depressions, of which the upper is the larger. In a few of the anterior centra the lower lateral depression is especially small, and restricted to the hinder half. The lower face (well seen in some of the distorted anterior centra) is flattened between the two longitudinally extended pits in which the bases of the hæmal arches are fixed. The gently arched ribs are long and slender, all reaching the ventral border of the fish. Each rib is impressed by a slight longitudinal groove, and its upper end is somewhat expanded where it fits loosely in the socket of a small parapophysis. This parapophysis, which does not appear to be firmly fixed in the pit of the centrum, is much more expanded in front of the socket than behind, and is in direct contact with the adjacent parapophyses. The arrangement is well shown in a drawing by O. P. Hay,[2] in which it was originally mistaken for a neural arch. In the anterior half of the abdominal region in the fossil the neural arches are accidentally removed, but further back several are in place,

[1] A. R. Crook, *Palæontographica*, vol. xxxix, p. 109, fig. 1, 1892; H. F. Osborn, Bull. Amer. Mus. Nat. Hist., vol. xx, pp. 377–81, pl. x, 1904; C. E. McClung, Kansas Univ. Science Bull., vol. iv, p. 243, pl. xii, 1908.

[2] O. P. Hay, Zool. Bull., vol. ii, p. 47, fig. 12, 1898; corrected in Bull. Amer. Mus. Nat. Hist., vol. xix, p. 56, 1903.

and there are a few scattered examples. Like the hæmals, they are loosely inserted in pits which extend nearly the whole length of the centra. As shown also by Hay,[1] each arch consists of a pair of thin laminæ, right and left, loosely apposed in the median plane, and surmounted by a long and slender neural spine, behind which a smaller and shorter rod-like process also rises upwards. Each arch slightly overlaps or clasps that next following, but without so well-defined a facet as that represented by Hay. Above some of the neural arches there are remains of the curved free fin-supports. In the caudal region both the neural and hæmal arches are firmly fixed in the pits of the vertebral centra as far as the origin of the caudal fin. Though longitudinally extended at their base of insertion, they do not overlap or interlock, but the tail is strengthened by the sharp backward curvature and inclination of all the neural and hæmal spines. The base of each neural arch is a little triangular expansion, strengthened by a vertical lateral ridge, but not bearing any posterior process, and not in contact with the next arch of the series. The base of each hæmal arch is shaped almost like the parapophysis in the abdominal region, but the hæmal spine is directly continuous with it.[2] The hæmal arches within the caudal fin are much thickened, in close contact, and articulate with the corresponding centra in open sutures.

There are no intermuscular bones in the caudal region or below the vertebral column in the abdominal region; but some may perhaps occur among the confused remains in the dorsal part of the abdominal region.

The left clavicle is seen from within, and exhibits the characteristic long and slender precoracoid arch crushed upon its inner face. Below it the base of the left pectoral fin appears, showing the bases of the four stout anterior rays in their natural position. The same rays of the right pectoral fin are well displayed lying over the ribs, the longest equalling in length a chain of about eighteen vertebræ. All these rays are gently arched bony rods, flattened on the outer face and marked only with a few longitudinal striations, evidently due to their structural fibres. The first, second, and fourth rays appear to be nearly complete to their distal end, where they scarcely taper and lack all traces of transverse articulations. The first ray is the stoutest and largest, with a sharply though irregularly rounded anterior border; the second ray is at least half as wide as the first ray, and its slender distal end, split by crushing, is preserved in the fossil to a greater length than the latter; the third ray, though seen on the left, is restored on the right side, but it is clear that its distal end cannot have been much expanded; the fourth ray is less stout, and shorter than the others. Behind these rays in another specimen in the British Museum (No. P. 10611) the pectoral fin is completed by three or four very short rays, which expand distally into a finely divided and articulated portion.

The pelvic fins are preserved apparently in their natural position, arising beneath about the forty-eighth vertebra. They are less than

[1] O. P. Hay, Zool. Bull., vol. ii, p. 51, figs. 15, 16, 1898.
[2] See figures by O. P. Hay, Zool. Bull., vol. ii, p. 48, figs. 13, 14, 1898 (in which the hæmal arch is described as neural, and vice versa).

half as long as the pectoral fins—a proportion very different from that observed in the restored paired fins in the specimens at New York and Lawrence (Kansas). The pelvic bones, which are well shown, are firmly articulated in the middle line at their base, and correspond in shape with those originally ascribed to *Portheus* by Cope.[1] The first fin-ray is much stouter and larger than the others, but it expands a little towards its distal end, and must have been finely divided and articulated at its extremity. The whole fin, in fact, resembles that of another specimen in the British Museum (No. P. 6326) which has already been figured.[2]

Of the median fins, the dorsal and anal are only imperfectly preserved, but the remains suggest that these fins were arranged as in *Chirocentrites*[3] and the living *Chirocentrus*, not as in the restorations at New York and Lawrence (Kansas). The anal fin clearly arises at the beginning of the caudal region, where both the fin-supports and the bases of the fin-rays are seen in nearly undisturbed series. It is uncertain, however, whether this fin extended as a low fringe backwards—it can only be noted that a few displaced short and broad fin-supports in the hinder part of the fossil may have belonged to such an extension. The dorsal fin is represented only by a few supports and imperfect rays at some distance behind the origin of the anal, and it seems probable that if it originally extended further forwards or backwards some traces would be exhibited.

The deeply forked and powerful caudal fin is already well known, and the new specimen confirms previous descriptions. There is clearly no sudden termination of the vertebral column with a urostyle as in *Chirocentrus*; but the five or six hindmost vertebræ form an upturned series, rapidly diminishing in size, as in the Elopines and other primitive teleostean fishes.

Remains of large and thin scales occur in various parts of both the abdominal and the caudal region, and their outer face often exhibits an irregular coarse tuberculation like that of the opercular bones. The rounded tubercles do not appear to be enamelled.

The new specimen of *Portheus* now described, while confirming previous descriptions in many respects, is thus of importance as showing for the first time the relative proportions of the paired fins and the probable true relationship of the dorsal and anal fins. It has already been pointed out that there are striking resemblances between *Portheus* and *Chirocentrites*, and the facts now published concerning the fins make it doubtful whether the species belonging to these two categories can any longer be referred to two distinct genera.

EXPLANATION OF PLATE XVIII.

Portheus molossus, Cope; nearly complete trunk, with the head of another individual; about $\frac{1}{17}$ nat. size. Obtained by Mr. Charles H. Sternberg from the Niobrara Chalk of Kansas, U.S.A. (Brit. Mus. No. P. 11125.)

[1] E. D. Cope, *Vert. Cret. Form.* (Rep. U.S. Geol. Surv. Territ., vol. ii, 1875), p. 192, fig. 9.

[2] A. S. Woodward, *Foss. Fishes English Chalk* (Mon. Pal. Soc., 1907), p. 101, fig. 28.

[3] J. J. Heckel, *Denkschr. k. Akad. Wiss. Wien, math.-nat. Cl.*, vol. i (1850), p. 203. See also A. S. Woodward, *Foss. Fishes English Chalk*, p. 99, fig. 25.

II.—The recent Discussion on the Origin of the Himalayas.

By R. D. Oldham, F.R.S., V.P.G.S., etc.

THE discussion on the origin of the Himalayas, started by Sir T. H. Holland's review [1] of Colonel Burrard's memoir, appears to have been led, by the concluding sentence of that review, into an unprofitable channel; for alike in the review and in the succeeding articles by Mr. Fisher [2] and Colonel Burrard [3] it seems to have been accepted that only two theories are applicable, firstly, Mr. Fisher's discussion of the theory of the disturbed tract contained in chapter x of the first and chapter xiii of the second edition of his *Physics of the Earth's Crust*, and, secondly, that developed by Colonel Burrard. Further, it is assumed that the former is dependent on the hypothesis of a fluid earth and the latter such as should follow from the hypothesis of a solid, highly heated, and cooling globe; the connexion, in either case, being so close that the acceptance of one or other hypothesis, of the constitution of the earth, necessitates the acceptance of one and the rejection of the other of the theories of the origin of the Himalayas. This, however, is not the case; Mr. Fisher's treatment of the disturbed tract, though originally a development of his theory of a fluid earth, and quite consistent with it, is equally consistent with the hypothesis of a solid earth, for it is hardly conceivable that the substance of the most solid of globes would not yield and flow under stresses of the magnitude and duration of those involved by the support of a mountain range such as the Himalayas, and, once such a flow commenced, there would be developed a system of quasi-hydrostatic support, and an isostasy caused by a species of flotation, which is all that is demanded by the general theory or by the adaptation to the particular case of the Himalayas contained in chapter xviii of the second edition of the *Manual of the Geology of India*. I, at least, have never regarded this as having any but a very remote bearing on the hypothesis of a solid or fluid condition of the interior of the earth.

On the other hand, Colonel Burrard's explanation, so far from being in accord with the hypothesis of a solid, cooling, earth, is in reality inconsistent with it, and his view, that, in such a globe, rifts would open by contraction from the surface downwards, is the reverse of what would actually take place. The conditions existing in a partially cooled solid globe are well understood; I believe they were first pointed out by Mr. Mellard Reade in 1876, but once indicated they became a truism, and may be very briefly explained. In such a globe there would be, on the outer surface, a crust, which has fully cooled and is incapable of further contraction, and in the centre a heated core, to which cooling has not penetrated; between the two lies a belt of material which is gradually losing heat and contracting in bulk. At the inner limit the contraction of this layer

[1] Sir T. H. Holland, "Origin of Himalayan Folding": Geol. Mag., 1913, p. 167.

[2] Rev. O. Fisher, "Rigidity of the Earth," Geol. Mag., 1913, p. 250; "Origin of Mountains," Geol. Mag., 1913, p. 434.

[3] Colonel S. G. Burrard, "Origin of Mountains": Geol. Mag., 1913, p. 385.

of cooling material must cause tension, as a diminution of the circumference is resisted by the uncooled central core; at the outer limit, where no further cooling takes place, the consolidated crust would be thrown into compression by the reduction in bulk of the material below, and somewhere between these two would come a zone where the radial and tangential contractions exactly balance each other, so that the material would neither be compressed nor extended.

The depth at this level of no strain beneath the surface would depend on the initial temperature of consolidation and the temperature gradient. The latter is approximately known, the former is doubtful; Mr. Mellard Reade, assuming a temperature of about 3,000° F., calculated the depth at about 1 mile; later, Mr. Fisher calculated a depth of about 0·7 mile for an initial temperature of 4,000° F., and of 2 miles for an initial temperature of 7,000° F. Of these three values for the initial temperature the lowest is the most probable, and the calculations show that any rift, which might be formed by tension in the 'sub-crust', could not reach the surface; it would originate at the level of the greatest tensional strain, which would lie at between 30 and 50 miles below the surface, and thence extend upwards and downwards, but could not reach upwards to within about a mile from the surface. These calculations never had any geological interest, beyond showing that the hypothesis of an originally highly heated, and gradually cooling, solid globe afforded no sufficient explanation of the structure of the earth's outer crust, as revealed by geological observation in the field; they have been rendered of little more than academic and historic interest by modern researches in radio-activity, which have, incidentally, provided a means by which fissures opening at the surface of the earth and penetrating downwards could be produced; for if the earth is an originally cold globe, getting gradually warmer, and expanding in bulk, by the action of radio-active material, then such fissures would naturally be formed; but in that case none of the consequences which Colonel Burrard has drawn from his rift would follow.

In all this I have not been arguing for or against a fluid or a solid earth, but against the introduction of an irrelevant issue. Whether the earth is a fluid or a solid globe seems a matter which concerns the astronomer, the physicist, or the mathematician, much more than the geologist; for all the processes which his observations demand appear to be equally compatible with either hypothesis. Nor am I arguing against Colonel Burrard's explanation as a whole; it may stand with the others as a possible hypothesis, to be tested and examined on its merits, but the tests must mostly be of a nature quite unconnected with geological observation. When, however, Colonel Burrard postulates the existence of a rift, or narrow band of subsidence, reaching 20 miles deep from the surface, we are brought face to face with a phenomenon for which we have no precedent, and before accepting it we must be satisfied, not only that it explains the geodetic facts, but that no other explanation, in closer accord with what is known of the geology of the regions, can be found.

No one can gainsay Colonel Burrard's contention that geologists must take count of the facts of geodesy, but it is equally true that geodesists must take count of the facts of geology, and in either case a distinction must be drawn between the facts of either science and the conclusions of individual workers, and again between those direct and inevitable deductions, which have almost the value of observed facts, and the more remote inferences, which may represent only one, or a part of one, of the possible explanations. Bearing this in view I propose to review, very briefly, the facts and explanations on either side.

On the geodetic side the facts may be summarized by taking the two stations Kurseong and Jalpaiguri, 25 miles apart, the first situated on the edge of the Himalayas, the second out in the Gangetic alluvium. At Kurseong the observed deflexion of the plumb-line is 46″ to the northwards; the calculated effect of the attraction of all visible masses, after allowance is made for the effect of isostasy, should have produced a deflexion of only 23″, leaving an unexplained residual of 23″ northerly deflexion. At Jalpaiguri the observed deflexion is only 1″ to the northwards; the calculated deflexion should have been 8″ to the northwards, leaving an unexplained residual of 7″ southerly deflexion. It may be well to point out that the values, both of the observed deflexions and of the unexplained residuals, depend on the assumed dimensions of the earth. The figures quoted are deduced from the dimensions now accepted by the Great Trigonometrical Survey of India as the nearest approach which has been made to exact accuracy, but, although the acceptance of different values for the size of the earth would alter the figures, no admissible variation would make a material change in the difference between them. For instance, if the earlier values, based on the Everest spheroid, are adopted, the observed deflexions at Kurseong and Jalpaiguri become 51″ and 6″ to the north and the unexplained residuals 28″ to the north and 2″ to the south, still leaving a difference of 30″ as between the two stations, which cannot be explained by the ordinary methods of geodetic calculation, and is only to be accounted for by some local peculiarity, or departure from average conditions. The explanation offered by Colonel Burrard is a deep and narrow rift, filled with material of less density than average rock, and situated between the two stations; there can be no question that the explanation is a feasible one, so far as the mathematics are concerned,[1] for the diminished attraction caused by the replacement of denser by less dense material would cause an apparent repulsion on either side of the rift, but before accepting this as the only, or even as the probable, explanation, we must see whether another cannot be found, in better accord with the known facts of geology.

The geological facts, which are pertinent to the question under consideration, may be simply expressed. All along the southern face of the Himalayas runs a great fault, or series of parallel faults, known as the boundary fault, on the north of which lie the older rocks of the Himalayas, and on the southern the upper Tertiary

[1] It may be added that a much lesser depth than 20 miles would not satisfy the conditions.

Siwaliks of the sub-Himalayas and the alluvium of the Gangetic plain. The Siwaliks were long ago shown, by Mr. H. B. Medlicott, to have been formed from the waste of the Himalayan range, under exactly similar conditions, and by the same rivers, as the alluvial deposits of the Gangetic plain, in other words to be merely the lower, older, and marginal, deposits of the same formation, now uplifted and exposed to denudation. The throw of the boundary fault cannot be measured directly, but it is certainly great, and may reasonably be estimated at between 10,000 and 15,000 feet, say between two and three miles. It may exceed or fall short of these limits in places, but is not likely to do so to any material degree.

On its southern margin the alluvium thins out over an old land surface. Between the two margins nothing can be determined, by direct observation, of the form of the rock floor, but the most natural deduction is, that the thickness of alluvium gradually increases from south to north, reaching its maximum at the great boundary fault, so that the Gangetic trough may be regarded as having the form of a very acute-angled wedge lying on its side, with the thick end towards the north. Mr. H. H. Hayden has recently shown that the pendulum observations of the Indian Survey support this interpretation,[1] but whether this exactly represents the case or not it is certain that the northern limit of the Gangetic trough is nearly vertical and of a depth of two or three miles, while at the southern limit the thickness of the alluvium is very small.

The effect on the direction of the plumb-line of a depression of this size and shape, filled with material which cannot have a density of more than 2·2, must be considerable, and I have had the curiosity to investigate it. The detailed results of the investigation would take up too much space to reproduce them here, nor are they suitable to this Magazine, but the general result may be indicated. I find that at the northern limit of the plain the effect would be an apparent repulsion of the plumb-bob, or in other words an apparent excess of attraction by the Himalayas, amounting to about 30″ if the depth of the alluvium is taken at 3·5 miles, and 18″ if it is taken at 1·75 miles. These values are not materially affected by any variation in the width of the alluvium. On either side of the boundary fault the deflexions decrease rapidly, but more rapidly to the south than on the north, for whereas, at 20 miles from the boundary on the north, there is still a deflexion of some 5″ or 6″ to the northwards, the northerly deflexion has almost disappeared at the same distance to the south, to be replaced, still further south, by a southerly deflexion, or apparent repulsion away from the Himalayas.

I have only indicated here the general nature of the effect which would be produced, but enough has been said to show that both in kind and magnitude it is very similar to that which has been observed, and for the explanation of which the 20 mile deep rift has been offered. Kurseong lies about 2 miles north of the main boundary fault, Jalpaiguri lies in the region where southerly deflexions should be expected, and the difference in deflexion, as

[1] Rec. Geol. Surv. Ind., xliii, pt. ii, pp. 163–7.

between the two stations, due to the effect of the less dense material filling the Gangetic trough, could not be less than 20″ and might amount to over 30″. From this it appears that without going beyond the known facts of the geological structure of the region—facts which are independent of any theory of the origin of mountains or the constitution of the interior of the earth—we can account for nearly, if not quite, the whole of the unexplained residual deflexions, which, instead of amounting to 23″ and 7″, would not come to more than 3″ or 4″, and the difference of 30″ would disappear or, at the least, be reduced to one of a few seconds of arc.

In all that has gone before I have avoided the question of the origin of mountain ranges in general, or of the Himalayas in particular, as, although I entered on the investigation, which I hope to publish in detail, with the hope that the limit of fairly established deduction might be carried further into the domain of pure speculation, I have found that the geodetic results do not give any material assistance. They have confirmed some conjectural inferences regarding the form of the rocky bed of the Gangetic depression, but on the question of the origin of the Himalayas, and of the nature of their support, the evidence is too uncertain and equivocal to be of any material value. This much, however, seems certain, that there is no good evidence for the existence of a rift of 20 miles or so in depth, as, once the known facts of geological structure are taken into consideration, the existence of such a rift would explain too much and introduce fresh difficulties even greater than those for which it was introduced as an explanation. Moreover, we must add to this negative evidence the positive fact that every observer, in every part of the range which has been visited, has found evidence of compression in precisely that zone where Colonel Burrard's postulate demands extension.

III.—The Plutonic Rocks of Garabal Hill.

By B. K. N. Wyllie, M.A., B.Sc., and Alexander Scott, M.A., B.Sc., Carnegie Research Scholars in the University of Glasgow.

(*Concluded from the November Number, p. 508.*).

At various places, such as the north side of Garabal Hill, the two Garabal burns (loc. iv and v, Fig. 1), and elsewhere, remarkably coarse rocks are found. A good section showing an apparent passage from tonalite to a coarse hornblendite is exposed at loc. v (Fig. 1). The rock in the bed of the burn is the normal tonalite, which appears to pass gradually to diorite. A closer examination of the unweathered rocks, however, shows that the passage is only apparent, and that the tonalite is clearly intrusive into the diorite with sharp junctions. The diorite near the junction is a rock of porphyritic aspect, containing large crystals of zoned diopside, abundant green hornblende and felspar, while the amount of quartz is small. A good deal of biotite is present, so that the rock might be described as a pyroxene-mica-diorite. Within a few feet the rock becomes coarser in texture, and the felspathic content diminishes, while there is a corresponding increase in the amount of amphibole. The latter is the green hornblende common to the diorites, and is occasionally replaced by mosaics of secondary actinolite. This substitution of felspar by hornblende, accompanied by an increase in the coarseness of the texture, continues till a hornblendite containing about 85 per cent of amphibole is reached. This rock is exposed for a distance of 20 yards to the south, and then the ground is obscured by peat, so that the other margin of the diorites cannot be seen. The hornblendite consists essentially of large crystals, more or less uniform in size and up to 3 cm. in length, of green hornblende which has wholly or partly altered to brown, the alteration commencing invariably from the centre. Occasional pyroxene cores are found, and these are generally surrounded by a narrow band of green amphibole, with brown beyond and finally green margins. The interstices are filled up with aggregates of quartz, felspar, and small green hornblendes, with occasional crystals of sphene. The finer-grained varieties of this sequence probably resembled very much the hornblendite which occurs along with scyelite in the Moine Gneiss regions.[1] Occasional schlieren, resembling those already described, occur among the coarser rocks. These are generally much more felspathic than the surrounding rocks and contain long prismatic hornblendes up to 6 cm. in length.

The brown hornblende of this series differs considerably from that of the davainites. In the latter case the mineral has developed directly from pyroxene and is invariably brown, while in the former case it has formed from original green hornblende, different degrees of transformation being visible, varying from incipient alteration at the centres to completely brown crystals. The mineral shows pleochroism from deep brown to yellowish green and has strong absorption. It is generally traversed by series of parallel dark bands arranged in lattice fashion and with small outgrowths, the whole somewhat resembling arborescent microlites. Teall[2] has described similar structures in amphiboles from Cornwall and Anglesey, and Thomson[3] also found them in hornblendites from Wicklow. In these cases the dark bands were assumed to be magnetite, formed by the magmatic resorption of pyroxene and consequent replacement by hornblende. In the Garabal Burn rock a careful examination, under a high power, of the ends of the bands and outgrowths showed that they are composed of aggregates of minute pale-green or colourless crystals, orientated in irregular fashion with respect to the main direction of the bands. It seems probable that the whole of the dark bands are made up of these minute crystals, the black colour being analogous to that observed in some opaque glasses, where the opacity is due to innumerable colourless longulites, which act as prisms and disperse and totally reflect the light, the degree of opacity varying with the amount of light totally reflected.[4]

[1] *Geology of Ben Wyvis*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 128–9.
[2] *British Petrography*, 1908, pp. 475–94.
[3] Quart. Journ. Geol. Soc., lxii, pp. 475–94, 1908.
[4] Cf. Pirsson, "Artificial Lava Flow and its Spherulitic Crystallisation": Amer. Journ. Sci., ser. IV, xxx, pp. 97–114, 1910.

General Petrology.

Excluding for the moment the tonalite, and also the possible relations between the diorites and the ultrabasic rocks, we propose to consider shortly the variations exhibited by each of these two groups. Although chemical analyses have not been made of all the rocks concerned, it seems most probable that there is no great variation in chemical composition in the ultrabasic series, save where impregnation by the latter acid intrusives has occurred. The basic end-member is a pure olivine rock altered to serpentine, and with a composition approximating to that of olivine. The other end-member is the pyroxenite. The mineralogical variation could therefore be shown diagrammatically by two curves, one representing the increase of pyroxene—including hornblende—from zero to approximately 100 per cent, while the other would represent the decrease of olivine from 100 per cent to nearly zero. The chemical differences are so small, therefore, that it seems to us that local variations in the conditions are sufficient to account for them. That the intrusion did not take place all at one time is shown by the presence of the veins of porphyritic rock, the end-product of the consolidation of the magma. Hence, in a magma of such size, consolidating over a considerable period of time, the conditions could not remain uniform. Local variations in temperature and pressure would involve local partial consolidation, and therefore areas of lower potential, with the result that a potential gradient would be set up. This would be followed by intermagmatic chemical reactions, involving the formation of other molecules and resulting in local excesses of ortho- or metasilicate molecules, with an ultimate consolidation as olivine or pyroxene, as the case may be.

A similar explanation would account for the variations of the diorites. Here again we have a comparative uniformity in chemical composition, the chief variation being in the mineralogical composition, in the substitution of pyroxene by hornblende and of hornblende by felspar and biotite. Supersaturation of the magma with respect to the ferromagnesian molecules would not occur everywhere at the same temperature, with the result that sometimes the high temperature modification, pyroxene, would form, sometimes the modification stable at lower temperatures, hornblende. The amount of water dissolved in the magma would also exert some effect, as the presence of water favours the formation of hornblende, in addition to reducing the viscosity. Local richness in potash would affect the production of biotite, while pressure would be an important factor owing to the probably high molecular volume of mica. A magma from which under certain conditions pyroxene would crystallize, would, under other conditions, give hornblende or biotite.[1] Hence it seems to us that there exists no necessity to postulate any differentiation beyond what would ensue from a locally heterogeneous magma.

We will now proceed to consider the Garabal Burn series in greater detail. The texture varies greatly, as in places chilled margins

[1] Cf. Doelter, Neues Jahrb. für Min., pt. ii, p. 178 et seq., 1888; pt. i, p. 1 et seq., 1897.

which might almost be called aphanitic in structure, are found in contact with the schist, while elsewhere the crystals of hornblende average 3 cm. in width, such coarse rocks generally occurring some distance from the margins. Another significant feature is the dyke or boss-like form in which the hornblendites occur.[1] It seems to us, therefore, that they may be regarded as the roots or cores of giant apophyses of the diorite projecting into the schist roof and now laid bare by denudation. The fine-grained margins would crystallize quickly and form an impermeable envelope, which would inhibit the escape of water and other mineralizers and favour the formation of hornblende. Hence these may be compared to pegmatites on a large scale, resembling the 'peridotite-pegmatites' of Loch Garabal in the mode of formation, though the latter are on a much smaller scale. The abundance of hornblende also favours the pegmatite theory, as mineralizers such as water are essential for its formation.

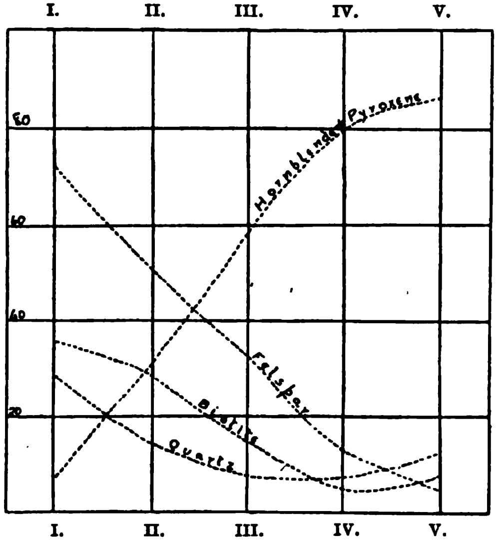


Fig. 3. Variation diagram of rocks of loc. v. Note: Quartz and biotite curves are drawn with scale of ordinates doubled.

The mineralogical variation in the rocks of this series is most easily shown by means of a diagram. A number of specimens were taken at approximately uniform distances from the tonalite and their mineralogical composition calculated by the Rosiwal method.[2] The hornblende increases from 7 to 84 per cent, while the felspar shows a complementary decrease from 70 to 5 per cent. Quartz, which is never very abundant, decreases to a minimum before the coarsest rock

[1] Hornblendites with brown amphibole have been described by Wright and Bailey in Colonsay, forming the margin of a syenite intrusion: *Geology of Colonsay* (Mem. Geol. Surv. Scotland); 1911, p. 29.

[2] No. 1 is an acid diorite from Meall Breac, while the others are from the Garabal Burn.

is reached and then increases slightly, while the biotite curve, though more irregular, as is to be expected, is very similar. The hornblende and felspar curves tend to become horizontal at the 'coarse' end where a nearly uniform rock is reached. Since these rocks show no normative quartz, the latter has obviously been formed from silica which has undergone hydrolysis at high temperatures. The increase in the water content as the coarse rocks are reached favours this.

The chemical composition, on the whole, does not show any great variations. We have analysed a specimen of the diorite close to the tonalite (VI) and one of the coarse hornblendite (VII).

	VI.	VII.	VIIa.	VIII.	IX.
SiO_2 . .	52·83	53·29	50·3	47·5	62·6
TiO_2 . .	1·82	1·41	1·6	—	—
Al_2O_3 . .	11·74	8·81	8·5	15·6	17·7
Fe_2O_3 . .	6·66	4·68	5·2	2·6	1·2
FeO . .	6·13	6·66	7·7	7·1	3·3
CaO . .	8·05	8·99	10·0	9·8	4·6
MgO . .	6·41	9·07	10·2	11·7	3·7
K_2O . .	2·06	1·87	1·6	1·5	2·5
Na_2O . .	2·67	3·21	3·2	1·4	—
H_2O . .	1·20	1·51	1·7	—	—
H_2O- . .	·20	·17	—	2·4	·7
CO_2 . .	nt. fd.	nt. fd.	—	—	—
P_2O_5 . .	·08	tr.	—	—	—
	99·85	99·67	100·0	99·7	99·7

VI. Diorite near junction with tonalite, Garabal Burn.
VII. Hornblendite, Garabal Burn.
VIIa. Approximate composition of brown hornblende of hornblendite (VII).
VIII. Diorite (very rich in biotite), Ben Damhain, anal. J. H. Player.[1]
IX. Granitite (tonalite), Ben Damhain, anal. J. H. Player.[2]

Though the silica is more or less constant, the hornblendite is somewhat more basic; that is, magnesia and lime increase at the expense of the alkalis, while the alumina decreases. These differences, however, are not sufficient to account for the mineralogical differences, as the 'norm' of the hornblendite shows a considerable amount of felspar. Hence we must conclude that the amphibole contains a considerable amount of alkali and lime, since the pyroxene which occasionally forms the core of the hornblende crystals is diopside. The amount of water has undoubtedly been an important factor in the production of the hornblende, though the relatively greater amount of magnesia must also have had an influence.

Origin of the Brown Hornblende.

The case is more difficult when we come to consider the alteration of the hornblende. There is no doubt that the mineral was originally green, and that the change originated from the centres of the crystals, unless in the case of those with diopside cores where a band of green

[1] Teall & Dakyns, loc. cit., p. 115. [2] Ibid., p. 115.

amphibole generally occurs round the diopside. It likewise seems most probable that the alteration took place after consolidation. The simplest explanation would seem to be that the change is due to the oxidation of the ferrous oxide and consequent passage of the iron from the basic radicles to the acid ones, to form ferrisilicates. The chemical analyses, however, are against this, as the hornblendite actually has less ferric iron than the diorite, while there is no reason to suppose that the brown colour of amphiboles is due essentially to ferric oxide: indeed, analyses of brown hornblende are recorded, containing only a small percentage of ferric iron. That the green hornblende is a metastable form is shown by the separation of the minute crystals of the dark bands. Since these are too small to be identified directly all that we can deduce respecting them is that they are probably monoclinic hornblende or pyroxene, since the rhombic modifications require special conditions such as would inhibit their formation in the solid state.

Two explanations suggest themselves:—

1. The brown colour may be due to ultramicroscopic crystals of the same nature as those of the feathery bands. As has been stated above, the colour of pitchstones and other glasses is often due to minute crystallites, which are too small to be resolved under the microscope, and the only evidence of the presence of which is the brown colour of the glass. Many pitchstones, too, show two generations of crystallites, one microscopic, the other sub-microscopic. Hence it is plausible to suppose that the brown colour of the hornblende has originated in this way, by the formation of innumerable crystallites of an order of magnitude lower than that of the crystals of the dark bands. The only effects on the pleochroism of the separation of such crystallites would be a uniform increase in the absorption, the difference for light waves traversing the crystal in different directions remaining practically constant, and a change in colour due to the total reflection of the light at the violet end of the spectrum.

2. On the other hand, the explanation may be that the metastable green hornblende breaks up into two more stable minerals, the minute crystallites of the dark bands and a brown hornblende. Analysis No. VIIa was obtained by deducting from analysis No. VII the amount of the various oxides which go to make up the other minerals in the hornblendite, quartz, orthoclase, andesine, and biotite, the amount of these present being calculated by the Rosiwal method. As these are only present in small amount, the error in assuming their composition as normal is negligible, and hence No. VIIa probably represents fairly closely the composition of the hornblende. Comparing this with analysis No. VI, it is seen that the amphibole of the coarser varieties contains a much greater proportion of sesquioxides than that of the finer types, as not only does more of the alumina in the latter rocks form felspar, but the iron partly crystallizes as biotite. In addition, the minute crystallites are colourless or nearly so, and hence may be assumed to be salts of lime or magnesia, with the result that their separation is accompanied by an enrichment of the residual material in 'total' iron. Thus we would have the

formation of an amphibole much richer in the oxides common to brown hornblende, accompanied by the separation of the bisilicates as the crystallites. There is very little difference between the optical properties of the two amphiboles. The extinctions are the same, as well as the positions of maximum and minimum absorption, the only difference being in the nature of the absorbed rays.

The "Newer Igneous Rocks".

The series of plutonic rocks which has been intruded into the Highland schists after the latter had been foliated are included under the general name of the "Newer Igneous Rocks". These intrusions, which are probably of Lower Old Red Sandstone age, show considerable lithological similarities. Granite usually composes the greater part, but diorites are of common occurrence, while ultrabasic rocks, on the other hand, are somewhat scarce. The only ultrabasic rocks which have been described are the peridotites of Garabal Hill, the kentallenites of Argyll,[1] the scyelites of the Moine Gneiss regions,[2] and the peridotites of the Coyles and Glen Doll,[3] each of which is accompanied by picrites. It is only in the last-named localities that we have a suite of rocks at all resembling those we have described. This includes an olivine-enstatite rock (saxonite), an enstatite-picrite, a porphyritic diorite with green hornblende, and some acid diorites. This is apparently a series of intrusions of decreasing basicity, with some rocks formed by amalgamation due to the later intrusions. A peridotite which occurs along with scyelite in Ross-shire seems to resemble the Garabal Hill wehrlite, but the scyelite itself, as well as kentallenite, are totally unlike anything occurring elsewhere, and seem to be more or less abnormal.

Wherever ultrabasic rocks occur in the Highlands they are clearly the earliest intrusion, and are usually followed by diorite and finally tonalite and granite. That some time elapsed between the various intrusions is certain, as all the evidence goes to prove that the peridotites were consolidated long before the diorites came up, and the latter had obviously crystallized before the granite intruded. Another significant feature is the absence of intermediate types. Thus at Garabal Hill we have nothing between the felspathic davainite, representing the least basic of the peridotites and with 43 per cent silica, and the hornblendites, the most basic diorite, with 49–52 per cent silica. Again, in Glen Doll, there is no rock intermediate between a picrite, containing a good deal of olivine, and a fairly normal diorite. A similar gap exists between the tonalite and diorite, for the acid diorite of Garabal Hill has about 54 per cent of silica, while the tonalite has never less than 62 per cent. Hence we have clearly three separate series of rocks, each more or less complete in itself and each showing not only the normal rock with slight

[1] Flett in *Geology of Oban and Dalmally* (Mem. Geol. Surv. Scotland), 1908, pp. 82–109.

[2] Flett in *Geology of Ben Wyvis*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 126–9.

[3] Barrow in *Geology of Braemar*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 73–83.

variations, but also the products of final consolidations in the form of schlieren; the porphyritic pyroxenite veins of Loch Garabal in the ultrabasic series, the hornblendites and the felspathic diorite-pegmatites of loc. v (Map, Fig. 1) in the diorites, and finally the aplites and acid pegmatites associated with the last intrusion.

For these reasons it seems to us exceedingly difficult to suppose that the whole of these rocks are "the result of the differentiation of an originally homogeneous magma".[1] Firstly, it is most improbable that a magma is ever in a state approaching homogeneity. Local variations of physical conditions as well as assimilation phenomena on the margins must be sufficient to keep the equilibrium heterogeneous. Secondly, while it is undoubtedly true that the basic elements would crystallize out first, the crystals thus formed would tend to sink, so that the upper parts of the magma would be relatively enriched in silica. Thirdly, the absence of intermediate types militates against the differentiation theory. This is also an argument against any theory of assimilation, as we should then expect a perfectly continuous sequence. Again, it is obvious that an original ultrabasic magma can never assimilate enough schistose material to form a tonalite, as the schist is more basic than the tonalite, while on the other hand an original acid magma could never form peridotite. In addition, it seems to us that difficulties arise when we come to consider the mechanism of differentiation. The application of Soret's principle[2] involves a large degree of diffusion and ignores, to some extent, the important rôle played by viscosity, so that its applicability is probably confined to marginal phenomena on a fairly small scale. Similar objections exist with regard to the principle of Gouy and Chaperon.[3] The difference of concentration between the top and bottom of a magma due to a gravity concentration of the heavy molecules in the dissolved state would be so small as to be negligible, unless the magma were of enormous depth.[4] It is most probable that gravity only operates on the heavy molecules where the latter form an immiscible liquid or have crystallized out. Hence it seems to us that a separate origin of the ultrabasic and the acid magmas must be postulated. While it is possible that the diorite has formed from the tonalite by assimilation, no such possibility exists with respect to the peridotites. It may be that the igneous material of the earth's crust is stratified to some extent and that the pyroxenites, etc., originated in some ultrabasic infraplutonic zone similar to that postulated by Fermor.[5] The almost invariable association of acid rocks with the earlier peridotites suggests that the former were forced up the margins of the earlier intrusions, which would constitute areas of crustal weakness and hence be the most ready outlet for the acid material. Any attempts to verify these ideas, however, are so much hampered by our

[1] Teall & Dakyns, loc. cit., p. 117.
[2] *Ann. de Chim. et de Phys.*, ser. v, xxii, pp. 293 et seq., 1881.
[3] Ibid., ser. VI, xii, pp. 384 et seq., 1887.
[4] Cf. Lehmann, *Molekularphysik*, i p. 483, etc., 1884.
[5] "Garnet as a Geological Barometer": Rec. Geol. Surv. India, xliii, pt. i, pp. 44–5, 1913.

incomplete knowledge of magmatic phenomena that they must remain as theories, and nothing more, for the present.

Note on the Diorites of Glen Lednock, Comrie.

Numerous isolated patches of diorite occur to the north-west of Loch Lomond, but no intrusion of any size is met with, except in Glen Lednock near Comrie. This occurrence is of interest because of the fact that the plutonic mass gradually passes to a hypabyssal variety of very similar composition. The plutonic rock is a fairly coarse biotite-diorite of uniform character, and is made up of mica, hornblende, felspar, quartz, and sphene, while magnetite, apatite, and zircon occur as common accessories. The mica is a deep-brown biotite with strong absorption, and is intergrown with a green hornblende, which is generally very much altered to chlorite. The felspar is partly andesine, partly orthoclase, and has apparently undergone crushing to some extent. Sometimes it is enclosed by the ferromagnesian minerals. Quartz is subordinate, while fairly large crystals of sphene occur occasionally. On the whole, this rock resembles the typical biotite-hornblende-diorite of Garabal Hill, though it has suffered much greater alteration. The rock is very uniform, the chief variation being in the relative amounts of biotite and hornblende. Very occasionally, anorthoclase occurs in addition to the other felspars.

The hypabyssal rock may be described as a diorite-porphyry, and has obviously formed as the result of quicker cooling of part of the magma. The phenocrysts include felspar, hornblende, and sphene, and show a tendency to occur in glomeroporphyritic aggregates. The felspars seem to be orthoclase, though they are generally so much altered that their determination is difficult. The hornblende has usually been replaced by fibrous aggregates of a secondary blue-green amphibole resembling actinolite; while occasionally the alteration has gone further and chlorite has developed. Sphene occurs as granular aggregates, intimately mixed up with the hornblende, though sometimes larger crystals are found. The groundmass is a micro-crystalline aggregate of quartz, felspar, biotite, hornblende, and granular sphene. The amount of quartz is small, but areas rich in sphene occur locally. The ferromagnesian minerals are found as small irregular crystals, and are accompanied by numerous cubes of magnetite. These rocks bear a close resemblance to the so-called porphyrites of Argyllshire,[1] not only in structure but also in the presence of two generations of hornblende.

Numerous veins of aplite occur in association with these rocks, differing, however, from those of Garabal Hill in some respects. The aplites of the latter area have granitic affinities, and are made up of quartz and alkali-felspar with subordinate muscovite. Those of Glen Lednock, on the other hand, are related to the syenite family, and contain orthoclase with abundant biotite, while quartz and plagioclase are subordinate.

[1] *Geology of Cowal* (Mem. Geol. Surv. Scotland), 1897, p. 103; Hill in *Geology of Mid-Argyll* (ibid.), 1905, pp. 103–15; Flett in *Geology of Oban and Dalmally* (ibid.), 1908, pp. 96–102.

Obviously, we have here an intrusion of the same nature as the diorite intrusion of Garabal Hill, but differing from the latter by the fact that part has undergone more rapid cooling, and hence has formed the diorite-porphyry. Analogous rocks, however, occur in the Strath Dubh Uisge valley, where a few dykes of very decomposed felspar-porphyry outcrop. An occurrence of diorite apparently passing to porphyrite has been described from Loch Melfort,[1] but the Geological Survey are of the opinion that the porphyrite is an earlier intrusion which has been altered by the diorite. In the island of Colonsay intrusions of augite-diorites have been found, grading to lamprophyres on the margins.[2] The junctions of the different types in Glen Lednock are very obscure, and hence the relations between the rocks cannot be ascertained.

IV.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[3]

(*Concluded from the November Number, p. 498.*)

(WITH FOLDING TABLE II.)

Solenopora.—The discovery of this genus in the Lower Carboniferous rocks of Westmorland is of considerable interest, as its occurrence here gives us some insight into the history of its wanderings between the time when we last recorded it in the Gotlandian rocks of the Baltic area and its subsequent reappearance in the Lower Oolite of Gloucestershire. Whether it lived in the Baltic area during the Devonian and Carboniferous periods is, however, still unknown. The fact of its occurrence in the Caradoc, Carboniferous, and Jurassic rocks of the British Isles would appear to point to its existence not far off during the intervening periods.

In Westmorland and Lancashire *Solenopora* occurs in considerable abundance near the local base of the Lower Carboniferous rocks, and contributes largely to the formation of limestone deposits. It is present wherever the lowest beds of the succession are exposed, as at Shap, Ravenstonedale, and Meathop, and must formerly have flourished over a considerable area.

Though bearing a general resemblance, both in hand specimens and in microscopic structure, to the Ordovician and Jurassic forms, it has recently been shown by Dr. G. J. Hinde to be specifically distinct.[4] It occurs as small, spheroidal nodules up to an inch in diameter, having a markedly lobulate outline embedded in compact and usually dolomitic limestones, and it is occasionally associated with oolitic structure. When fractured it exhibits the compact porcellanous

[1] Flett in *Geology of Oban and Dalmally* (Mem. Geol. Surv. Scotland), 1908, p. 69.

[2] Wright & Bailey, loc. cit., pp. 33–4.

[3] Edited and slightly abridged with the author's permission from the original Address as delivered at Birmingham, before Section C at the British Association meeting.

[4] Geol. Mag., Dec. V, Vol. X, p. 289, 1913.

texture and pale brownish tint characteristic of other species of this genus, while weathered surfaces frequently show a concentric and occasionally a radially fibrous structure. The profusion of this form in Westmorland would lead one to expect its occurrence in other districts where the lowest Carboniferous zones are developed; but so far as I am aware, no such occurrence has yet been recorded. It may be of interest, therefore, to mention here that a few years ago my friend Mr. P. de G. Benson brought me a specimen of rock from near the base of the succession in the Avon Gorge, which on cutting I found to contain several examples of *Solenopora* identical with the Westmorland form.

Mitcheldeania.—The specimens of *Mitcheldeania Nicholsoni* originally described by Mr. Wethered were obtained from Wadley's Quarry, near Drybrook, Mitcheldean, from the Lower Limestone shales near the base of the succession. Professor Sibly, who has recently made a careful study of the Lower Carboniferous succession in the Forest of Dean,[1] has traced this algal layer over a considerable area, and considers it to represent an horizon near the top of K.II. of the Bristol sequence. He has also noted examples of *Mitcheldeania* at a higher level—namely, in the Whitehead Limestone, an horizon corresponding probably to the base of C.2. During a recent visit to the Mitcheldean district I collected specimens from the lower shales and also from the Whitehead Limestone, and, thanks to Professor Sibly's kind directions, I was able to see numerous sections in which he has found this algal development. There can be no doubt that *Mitcheldeania* is here an important rock-forming organism at least at two horizons in this district, and that it occurs over a considerable area. Interesting as the development of *Mitcheldeania* in the Forest of Dean undoubtedly is, its real home in Britain is in North Cumberland and along the Scottish Border, where it flourished to a remarkable extent in the shallow-water lagoons which spread over so large an area in the North of England during early Carboniferous times. Over the greater part of North Cumberland and the east of Roxburgh we find a remarkable development of algal limestones in the formation of which *Mitcheldeania* plays a very important part. It is met with especially at two horizons—an upper one, lying immediately below the Fell Sandstone, and a lower one in the middle of the underlying series of limestone and shales. The lower horizon is especially interesting on account of the thick masses of limestone composed almost entirely of algal remains. Though *Mitcheldeania* forms the basis of this reef-like development, it is accompanied by other algal forms, especially bundles of the minute tubules of *Girvanella* together with coarser tubes reminding one of the *Sphærocodium* deposits of Gotland; in places again the marked concentric coatings resemble certain forms of *Spongiostroma*. The substance of the reef has frequently formed round the remains of Orthoceratites—indeed, the chief layer is usually associated with remains of these Cephalopoda. With other layers occur tubes of *Serpulæ* and remains of Ostracoda. In addition to the limestone of this massive reef, abundant nodules of *Mitcheldeania* lie scattered through the calcareous shales both above and below.

[1] Geol. Mag., Dec. V, Vol. IX, p. 417, 1912.

The upper horizon from which Nicholson obtained his type-specimen of *M. gregaria* at Kershope Foot forms a compact limestone several inches thick. It is made up of small spheroidal nodules about half an inch in diameter, and occurs a short distance below the Fell Sandstone. It can be traced over the whole of North Cumberland and north-west Northumberland from near Rothbury on the east to the Scottish Border at Kershope Foot, and from the headwaters of the Rede in the north to the Shopford district in the south. This layer must therefore have been originally deposited over an area of at least 1,000 square miles. The horizon of the upper band is almost certainly that of the C zone of the Bristol sequence.[1] It is quite possible, therefore, that it is contemporaneous with the Whitehead Limestone of Mitcheldean. This supposition receives support from two other pieces of evidence. In the beds underlying the *Mitcheldeania gregaria* band in North Cumberland occur calcareous nodules largely made up of tubes of *Serpulæ*—an organism which is completely absent from the Westmorland succession, but which is reported by Professor Sibly from the lower limestone shales containing *Mitcheldeania* in the Forest of Dean district. Again, this upper algal layer in Northumberland and Cumberland is almost immediately overlain by the Fell Sandstone Series, while the Whitehead Limestone at Mitcheldean passes immediately upwards into a sandstone, the Drybrook Sandstone of Professor Sibly, which was originally correlated with the Millstone Grit, but was shown by Dr. Vaughan in 1905 to belong to the Lower Carboniferous Series. It would be interesting if further researches should prove the existence of a former gulf at the end of Tournaisian times, running from the Forest of Dean to the east of North Wales, through North Cumberland to the southern slopes of the Cheviot Isle, with a branch given off eastward into Westmorland.

In any case it is a remarkable fact that we have a great development of algal deposits at this period in Gloucestershire, Westmorland, Lancashire, North Cumberland, and Northumberland.

Ortonella.—This form, as already mentioned, occurs in great abundance in the algal band in the '*Athyris glabristria* zone' of the North-West Province. It is found in spherical nodules up to the size of a small orange. In microscopic sections it resembles *Mitcheldeania* in so far as it consists of a series of tubes growing out radially from a centre. It differs, however, from this genus in many important respects. All the tubes are approximately of the same size, and there is no evidence of alternating coarse and fine tufts arranged concentrically, as in the case of *Mitcheldeania*. Further, the tubes are not undulating as in that genus, and therefore in thin slices lie for a long distance in the plane of the section. They are much more widely spaced and show marked dichotomous branching, the bifurcations making a nearly constant angle of about 40°, and there is a strong tendency for the branching to take place in several tubes at about the same distance from the centre of growth, producing a general concentric effect in the nodule.

[1] *Geology in the Field*, pt. iv, p. 683, and Q.J.G.S., vol. lxviii, p. 547, 1912.

The diameter of the tubes is decidedly less than those in *Mitcheldeania*, being usually little more than half the size of the larger tubes of *M. gregaria*. The nodules of this genus occur in great profusion, contributing largely to the formation of the shaly dolomite at the base of the '*P. globosus* band' throughout the Shap, Ravenstonedale, and Arnside districts in Westmorland and Lancashire.

In addition to these genera there occur also two other encrusting calcareous growths which require mention. The first of these appears in thin sections in the form of a 'festoon-like' growth, surrounding fragments of Calcareous Algæ, especially *Mitcheldeania* and *Ortonella*. I have met with it abundantly in the 'Algal band' in the north-west of England, but it also occurs not infrequently associated with *Mitcheldeania* in the Whitehead Limestone in the Forest of Dean, while a similar structure occurs associated with *Mitcheldeania gregaria* in North Cumberland.

The other deposit is the form already alluded to under the term *Sphærocodium*, which I have found forming considerable masses of rock in many districts where the Lower Carboniferous beds are exposed, not only in Westmorland and North Cumberland, but also in the Bristol district, the Forest of Dean, and South Wales.

Foreign Carboniferous.

From its general similarity to the British deposits we might expect to find examples of an algal development in some portion of the Belgian Lower Carboniferous succession. As already mentioned, large masses of encrusting calcareous deposits have been described by Gürich[1] from the Visean Limestones of the Namur Basin as *Spongiostroma*, etc., which, though referred by him to the Rhizopoda, may very well be calcareous precipitates deposited by algal influence. Many of these deposits are similar to those mentioned above from British rocks.

No undoubted remains of Calcareous Algæ have, however, yet been recorded from these Belgian rocks. It may be of interest, therefore, to mention the recent discovery by Professor Kaisin, of Louvain, of certain algal remains in the beds overlying the Psammites-de-Condroz at Feluy on the Samme. The form found here resembles *Ortonella* of the Westmorland rocks, but the tubes are much finer, and it may turn out to represent a species of *Mitcheldeania*. During a recent visit to Belgium I had the pleasure of visiting the Comblain-au-Pont Beds, in the Feluy section with Professor Kaisin, and, although these beds have been previously classed as Devonian, I agree with him that they probably belong to the base of the Carboniferous and correspond approximately to K of the Bristol sequence. In the company of Professor Dorlodot and Dr. Salée, I also visited the chief sections of the Visean, and we succeeded in discovering at least three horizons at which nodular concretionary structures, probably referable to algal growths, occurred.

In 1908 Schubert (Jahrb. d. k. k. geol. Reichsanstalt, 1908, Bd. 58, Hft. 2, pp. 347, 382, pl. xvi, figs. 8–12) published descriptions of two new forms of the Siphoneæ—*Mizzia* and *Stolleyella*—from the

[1] Mém. du Musée Roy. d'Hist. Nat. de Belgique, t. iii, 1906.

Fusulina Limestone of the Velebit district in Dalmatia, while later, in 1912 (Verh. d. k. k. geol. Reichsanstalt, 1912, p. 330), he records further examples of these genera from specimens, collected by Koch, of rocks of the same age in Croatia. The same genera have also been recorded by Karpinsky from the Fusulina Limestone of Japan (Verh. d. Russ.-kais. Min. Gesell. St. Petersb., ser. II, Bd. 46, 1908, p. 257, pl. iii).

Still more recently another form of *Girvanella* has been described by Yabe from the (?) Carboniferous rocks of San-yu-tung and other localities in China under the name of *G. sinensis*.[1]

Permian and Trias.

In Britain I have met with no reference to the presence of Calcareous Algæ in rocks of this period, but quite recently Mr. Cunnington, of H.M. Geological Survey, sent me a few nodules from the base of the Permian near Maxstoke; in thin sections they resemble very closely specimens of *Spongiostroma* from the Carboniferous Limestone described above.

On the Continent masses of limestone, composed almost entirely of remains of *Diplopora* and *Gyroporella*, have long been known from the Muschelkalk and Lower Keuper beds of the Eastern Alps, notably the Mendola Dolomite, the Wetten Limestone of Bavaria, and from similar horizons in Tyrolian Alps. In the Lombard Alps the same facies reappears, and *Diplopora annulata* occurs abundantly in the well-known Esino Limestone above Varenna, while recent work by Cayeux (C. R. Acad. Sci., Paris, tome clvii, p. 272, 1911, and Exploration Arch. de Délos, Paris, vol. iv, pt. i, 1911), Négris (C. R. Acad. Sci., Paris, tome clv, p. 371, 1912), and Renz (Centralb. f. Min., 1911, pp. 255, 289, and ibid., 1912, p. 67; also Jahrb. österr. geol. R. A., lx, pt. iii, p. 451, 1910) on the Triassic rocks of the mainland of Greece and the Cyclades shows the wide distribution of the Algal limestones in the south and south-east of Europe.

In 1891 Rothpletz[2] showed that certain spherical bodies in the Triassic beds of St. Cassian, formerly regarded as oolitic structures, were in reality algal growths, and referred them to a new genus, *Sphærocodium*, on account of their apparent resemblance to the living form *Codium*. He describes them as encrusting organisms forming nodules up to several centimetres in diameter. They contribute substantially to the rocks in which they occur, and are found especially in the Raiblkalk, the Kossenerkalk, and the Plattenkalk.

Jurassic.

The Mesozoic rocks of Britain contain but few examples of marine algal limestones, and important occurrences are confined to the Jurassic rocks. The forms met with are limited to two genera, *Girvanella* and *Solenopora*.

Tubes of *Girvanella* occur fairly abundantly in the British Oolites, especially in the well-known Leckhampton Pisolites, and Mr. Wethered, who has made a special study of oolitic structures, appears inclined to refer all oolitic structures to organic agency of this nature.

[1] H. Yabe, Science Reports of the Tâhoku Imp. Univ., ser. II, Geology, vol. i, No. 1, Japan, 1912.

[2] Zeitsch. d. deut. Geol. Ges., vol. xliii, pp. 295–322, pls. xv–xvii, 1891.

The examples of *Solenopora* met with in the Great Oolite[1] and Coral Rag are of special interest. In both cases they attain very much larger dimensions than any species yet discovered in the Palæozoic rocks.

At Chedworth, near Cirencester, I have collected masses of *Solenopora jurassica*, measuring up to a foot across, in which the original pink tint is still so conspicuous on freshly fractured surfaces as to give rise to the local appellation of 'Beetroot Stone', and the colour also reminds one of the red algæ growing in great profusion at the present day in the Gulf of Naples.

It is also recorded from the same horizon by Dr. Brown[2] from near Malton in Yorkshire, and also, on the authority of the late Mr. Fox Strangways, by Rothpletz.[3]

In Yorkshire, however, one form undoubtedly occurs at a higher horizon, namely, in the Coral Rag of the Scarborough district, where it is well known to local collectors. Specimens which I have collected from this horizon at Yedmandale and Seamer also attain a considerable size—up to 3 inches in their longest dimension.

The name *Solenopora jurassica* was given by Nicholson in manuscript to specimens from Chedworth, and was adopted by Dr. Brown in his description of the specimens from both Chedworth and Malton in Nicholson's collection.

Rothpletz points out that specimens examined by him from Yorkshire differ from the genotype in the fact that the cells are typically rounded in cross-section and by the absence of perforations in the cell-walls, and he therefore proposes to separate it as a new genus *Solenoporella*. It seems probable that some confusion has arisen between the specimens to which Nicholson originally gave the name of *S. jurassica* from the Great Oolite of Chedworth and other specimens from Malton from a higher horizon[4]—the Coral Rag. I have collected specimens from both horizons and consider that the Chedworth specimens, to which the name *Solenopora jurassica* was originally given, represent a species of true *Solenopora*, showing closely packed cells with polygonal outline in tangential section; the form from the Coral Rag of Yorkshire, with distinct circular outline to the tubes in tangential section, is specifically, if not generically distinct, and is that described by Rothpletz as *Solenoporella*.

If this view be correct we should continue to speak of the specimens from the Great Oolite at Chedworth as *Solenopora jurassica*, while those from the Coral Rag of Yorkshire must be known as *Solenoporella* sp., Rothpletz.

Foreign Jurassic.

In foreign Jurassic rocks the recorded occurrences of Calcareous Algæ are surprisingly few.

Quite recently, however, Mr. H. Yabe[5] has described a new species of *Solenopora*, under the title *Metasolenopora Rothpletzi*, from the

[1] Proc. Cot. Nat. Club, vol. x, p. 89, 1890.
[2] Geol. Mag., Dec. IV, Vol. I, pp. 145 et seqq., 1894.
[3] Kungl. Svenska Vet. Akad. Handl., Bd. xliii, No. 5, 1908.
[4] See Fox Strangways, Geol. Mag., Dec. IV, Vol. I, p. 236, 1894.
[5] Sci. Rep. Tâhoku Imp. Univ. Japan, 1912.

Torinosu Limestone, Japan. This discovery is of interest, as it carries the known occurrence of *Solenopora* up to the base of the Cretaceous, in which formation *Lithothamnion* appears and thenceforward becomes the chief representative of the rock-building Coralline Algæ.

Cretaceous.

We here reach the period when *Lithothamnion* and its allies begin to make their appearance. They have not yet been recognized in British rocks, but are widely distributed in deposits on the Continent. They occur in the Cenomanian of France, in the Sarthe and the Var, but especially in the Danian of Petersburg, near Maestricht.

Other forms which may be mentioned are *Diplopora* and *Triploporella*. The former is met with abundantly in the Lower Schrattenkalk in certain districts, especially Wildkirchli, where it plays a considerable part in the formation of the deposit.[1]

Tertiary.

In Britain no example of marine Calcareous Algæ have, so far as I am aware, yet been reported, but considerable deposits of freshwater limestone, rich in remains of *Chara*,[2] have for long been known from the Oligocene of the Isle of Wight.

Foreign Tertiary.

On the Continent, however, thick deposits rich in *Lithothamnion* and *Lithophyllum* have been known for many years. Of these I may mention especially the well-known Leithakalk of the Vienna Basin and Moravia. It will be remembered that it was these deposits which formed the subject of Unger's important monograph in 1858.[3]

Conclusions.

The facts given above regarding the geological distribution and mode of occurrence of these organisms lead us to several interesting conclusions. In the first place there can be no doubt from the examples described above that they play a very striking part as rock-builders at many different horizons in the geological series. At the same time it is evident that not only are certain forms restricted to definite geological periods but also that they had a wide geographical range, and on this account these organisms will often be found valuable as zonal indices either alone or in conjunction with various other organisms. As an example of this wide distribution we may cite *Solenopora compacta*, which flourished so abundantly during Llandeilo–Caradoc times not only in the Baltic area and Scotland but also in England, Wales, and Canada; again, the wonderfully persistent development of the *Rhabdoporella* facies over the whole of the Baltic area at the close of Ordovician times was of so marked a character that even boulders of these rocks scattered over the North German plain can be made use of in tracing the direction of flow of the ice-sheet during Glacial times.

[1] Arbenz. Vierteljahrsschr. Naturf. Ges. Zurich, vol. liii, pp. 387–92, 1908.

[2] This form, though till lately included among the green algæ, is now usually placed in a distinct group—the Charophyta.

[3] Denksch. k. Akad. Wiss. München, vol. xiv, p. 13, 1858.

To take examples nearer home. The '*Ortonella* Band' found throughout Westmorland and North Lancashire near the summit of the Tournaisian occurs so constantly at the same horizon as to constitute one of the most valuable zonal indices in the succession in the North-West Province, and can not only be used with the greatest confidence for correlating widely separated exposures, but it has also afforded valuable evidence of tectonic disturbances. Other examples are supplied by the '*Girvanella* Nodular Band' at the base of the Upper Dibunophyllum Zone, and the *Mitcheldeania gregaria* beds in the North of England and in the Forest of Dean.

Again, the presence of these organisms at particular horizons furnish us with interesting evidence as to the conditions which obtained during the accumulation of the deposits in which they occur.

At the present day Calcareous Algæ flourish best in clear but shallow water in bays and sheltered lagoons. As a good example we may take the Algal banks in the Bay of Naples, described by Professor Walther,[1] where *Lithothamnion* and *Lithophyllum* flourish to a depth of from 50 to 70 metres. There is seldom any muddy sediment on these banks, though detrital limestone fragments are widely distributed. Another interesting point is the constant association of fossil Calcareous Algæ with oolitic structure and also with dolomite.

Thus oolites occur in connexion with *Solenopora* in the Lower Cambrian of the Antarctic, in the Craighead Limestone at Tramitchell, in the Ordovician rocks of Christiania and the Silurian of Gotland, and in the Lower Carboniferous Limestone of Shap; while in the Jurassic rocks of Gloucestershire and Yorkshire this genus occurs associated with the most typical oolitic development to be met with in the whole geological succession. Though Mr. Wethered has made out a good case for the constant association of *Girvanella* tubes with oolitic grains there are many cases in which this association cannot be traced. M. Cayeux[2] in writing of a mass of *Girvanella* from the ferruginous oolites of the Silurian rocks of La Ferrière-aux-Etangs expresses his opinion that *Girvanella* encrusts the oolite grains but does not form them, and that it is really a perforating alga of a parasitic nature.

The presence of dolomites in connexion with algal growths at different geological horizons appears to show that the beds have accumulated under definite physiographical conditions similar to those which obtain to-day in the neighbourhood of coral reefs. Such lagoon conditions would tend to come into existence during periods of subsidence or elevation, and this is just what we find when we examine the periods at which these reefs are most persistent.

Thus the Girvan Ordovician lagoon-phase occurred during an elevation which culminated with the deposition of the Benan Conglomerate; the Lower Carboniferous 'Algal band' in Westmorland was laid down during the subsidence which followed the Old Red Sandstone continental period, while the Upper *Girvanella* Nodular band occurred

[1] Zeitsch. deut. Geol. Ges., 1885, p. 229. Abh. Königl. Preuss. Akad. Wiss., 1910.

[2] Comptes Rendus Acad. de Sci. 150, 1910, p. 359.

...ATIONS.	BRITISH	LOCALITIES.	...N AND ...PPINES.	AUSTRALIA AND MADAGASCAR.	ANTARCTIC.
Tertiary .	—	—	—	—	—
...e . .	—	—	...tham- ...c ...ppines.	—	—
...ne . .	—	—	—	*Lithothamnion*: North Madagascar.	—
. . .	—	—	—	—	—
...ous . .	—	—	—	—	—
...c . .	—	—	...oleno- ...: Japan ...osu ...stone).	—	—
...ock.	—	—		—	—
Rag.	? *Solenoporella* .	Yedmandale, Seamer, Ruston, etc., and Malton.	—	—	—
... Oolite.	*Solenopora jurassica*	Chedworth, near Cirencester.	—	—	—
. . .	—	—	—	—	—
...n . .	? *Spongiostroma* .	Maxstoke, near Coventry.	—	—	—
...iferous— & Lower .	—	—	...a, ...evella: ...aka, ..., Japan.	—	—
...of Upper ...ophyllum	*Girvanella* . .	Coldstream, Penygent, Humphrey Hd., etc., Tortworth, Clifton.	...nella ...sis: ...iferous? ...n.	—	—
...ris glaria zone.	*Ortonella* . . .	Shap, Orton, Ravenstonedale, Meathop, etc.	—	—	—
	Solenopora Garwoodi	Shap Abbey, Stone Gill, Meathop, Clifton.	—	—	—
	Mitcheldeania gregaria, Mitcheldean Whitehead Group	Scottish Border, Cumberland, Northumberland.	—	—	—
	M. Nicholsoni, Mitcheldean, Lower Limestone Shales	Scottish Border and Cumberland.	—	—	—
	? *Spongiostroma* .	Widely distributed at several horizons, especially at Orton.	—	—	—
...an . .	? *Girvanella* . .	Hope's Nose Limestone.	—	—	—
...a— ...ow.	—	—	—	*Girvanella* ? *Mitcheldeania*.	—
...ock.	*Girvanella problematica* (?)	Mayhill, Malvern, etc.	—	—	—
...cian— ...: Caradoc. ...illan Series ...ehouse ...).	*Solenopora lithothamnioides*	Shalloch Mill, Girvan.	—	—	—
...leilo- ...loc	*Girvanella problematica*	Girvan district.	—	—	—
...har and ...head ...tone).	*Solenopora compacta*, var. *Peachii*, *S. fusiformis*, *S. filiformis*	Girvan district; Hoar Edge, Shropshire; Yat Hill, Radnorshire.	—	—	—
...an . .	—	—	—	*Girvanella*.	*Solenopora* (Beardmore Glacier).

[1] Ravenstonedale.

when the marine period of the Lower Carboniferous was drawing to a close and a general elevation was taking place. Similar conclusions could be drawn from the Gotlandian and other periods recorded above.

In conclusion I venture to express the hope that however incomplete the account of the succession of forms which I have given may be, it may nevertheless help to stimulate an interest in these rock-building Algæ and encourage geological workers in this country to turn their attention to a hitherto neglected group of forms of great stratigraphical importance.

In the accompanying Table II are set out the more important Algal horizons so far described in the Palæozoic and Mesozoic rocks, together with a few typical occurrences of Tertiary age, but the table makes no claim to be exhaustive, as additional evidence of the importance of these organisms is constantly coming to hand; thus since the publication of the last number of this Magazine I have received from Professor Rothpletz[1] a description of a new form of Spherocodium, *S. zimmermanni*, which he finds playing an important part in the 'so-called conglomerate' in calcareous sandstone near Liebichan Silesia, formerly classed as Culm, but which has recently been shown by Zimmermann to be of Upper Devonian age.

V.—The Sub-crag Flints.

By J. Reid Moir, F.G.S.

At the meeting of the British Association held at Birmingham last September, Professor W. J. Sollas, F.R.S., read a paper in which the Sub-crag flints I have discovered were rejected as not being of human workmanship. Professor Sollas mainly based his arguments upon certain flints found upon the seashore at Selsey Bill, Sussex, many of which have been collected by Mr. E. Heron Allen of that place. In August of this year I paid a visit to Selsey and, owing to the kindness of Mr. Heron Allen, was enabled to carefully examine his collection of flints and the exact places on the shore from which they were derived.

The conclusions I arrived at regarding these specimens and their method of fracture are as follows:—

An examination of the flints in Mr. Heron Allen's collection from the surface of the Eocene clay at Selsey Bill clearly shows that they differ widely both in mineral condition and 'patination', and do not belong to one geological period. When each series is arranged apart the specimens are seen to resemble very closely those found in East Anglia (1) below the Red Crag, (2) in the Middle Glacial Gravel, and (3) in the Chalky Boulder-clay.

The occurrence of flints of these three series at one horizon in the South of England is of some interest and importance, and seems to indicate the breaking up of these deposits and subsequent deposition of their material at the spot where they are now found. The specimens

[1] "Über *Sphærocodium Zimmermanni* aus dem Oberdevon Schlesiens": Jahrb. d. k. Preuss. Geol. Landesanstalt, 1911, Bd. xxxii, T. ii, Hft. i, p. 112, pls. 4, 5.

have naturally had a lot of rough usage while being transported from one site to the other and have also suffered considerable disintegration, as is clear from the cracked condition of the lumps. Prolonged examination of the East Anglian flints from the three horizons mentioned has shown that those below the Red Crag are hard and sound, while those from the Middle Glacial Gravel and Chalky Boulder-clay are much more easily cracked and broken up.

It is therefore very interesting to find that the same rule holds good at Selsey, where specimens, apparently of the same age as the Sub-crag samples of East Anglia, are not so much broken as those which appear to have come from Middle Glacial and Chalky Boulder-clay deposits.

The 'Sub-crag' specimens from Selsey are in some cases humanly flaked, and the flaking is in every way the same as that seen upon the East Anglian flints. The flakes are large and have been removed by blows of considerable force delivered in a vertical direction and resulting in smooth, clean surfaces, generally free from conchoidal rippling. Fissures or small 'splits', radiating from the point of impact, are very often developed upon the surface of the flakes, which frequently required repeated blows to detach them from the block. The flints also exhibit a dark rich brown colour, and in many cases well-marked 'weathered-out' scratches. These peculiarities are to be seen upon the East Anglian Sub-crag specimens, and moreover the forms of worked flints from the two sites are almost exactly similar.

(Mr. Heron Allen tells me that the smaller Sub-crag types such as borers, scrapers, etc., have not been found at Selsey.)

Out of the large series of Selsey flints about twelve have been definitely worked by man, and only four of these were undamaged and in a good state of preservation. These were all of a Sub-crag type; some of the others may at one time have exhibited human work, but if so, subsequent natural fracturing has effectually disguised it.

In order to demonstrate that the flints with cracks running through their mass could easily be disintegrated, I dropped one upon a tougher specimen, and, as I expected, the impact was sufficient to shatter it in pieces. Some of these fragments, which of course bore no real resemblance to man's work, were of a somewhat suggestive shape, and if subjected to some amount of rolling by the sea might very well deceive an unpractised eye.

A visit to the exposure of these flints on the foreshore confirmed the belief that the sea is at the present day breaking up the blocks, and a single tap of the hammer is often enough to reduce them to fragments. It is clear that the large majority of the Selsey specimens have been fractured in the manner I describe, and a comparison of the fractured surfaces with those produced by my experiment shows an exact agreement. There is the same dull, lustreless appearance, the same uneven 'hackly' fracture, and the same indisputable evidence that the flint has broken along the lines of least resistance. There is also no sort of resemblance in these fractures to those on the other specimens which have been produced by heavy well-directed human blows.

The fact that the Selsey specimens are found upon the present sea-shore has induced some observers to assert that all the fractures have been caused by wave-action on the shore, and that it is possible to observe the process actually going on. The latter fact is not denied, and indeed has been tested by experiment, but the fractures so produced are quite distinct from those attributed to human agency. It is also quite clear that wave-action on the present beach has simply removed typical 'natural' flakes, that is those which have been caused by blows falling on an edge instead of at the side of it, the former showing prominent ripple-marks owing to the blows being oblique instead of vertical. These 'natural' flakes are never very large, and often cut deeply into the flint, developing into a 'step' at the end opposite to the point of impact.

The alleged discovery of a rostro-carinate 'implement' fixed in the Eocene clay and in process of manufacture must, I think, be received with very great caution, especially as it appears that the ventral plane, from which the flakes are generally removed to form the carina, was turned towards the shore, and therefore not exposed to the hypothetical battering of the stones brought in by the sea.

The small series of flints collected by Mr. Heron Allen shows a fundamental difference, which is best explained by the difference known to exist between human and natural flaking, the presumed implements being picked out with ease from others which are obviously formed by natural agencies. Moreover, there appear to be no transitional forms, the two series being sharply enough defined for those familiar with the fracture of flint. The 'human' series examined on this occasion contains no typical rostro-carinate implements, and the superficial resemblance of others to that type will not bear investigation.

VI.—On some Foraminifera from the Eocene Beds of Hengistbury Head, Hampshire.

By Frederick Chapman, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

In the March Number of this Magazine Mr. Cowper Reed recorded the interesting discovery of a series of fossils which points to a Bartonian horizon for the Hengistbury ironstone. Upon reading this paper I was reminded of some chocolate-coloured clays with Foraminifera which I had collected from a seam between the ironstone bands at Hengistbury Head in August, 1895. The washings from these clays afforded abundant tests of arenaceous forms; and since, so far as I am aware, no Foraminifera have yet been recorded from this locality, it may be of some interest to publish the results of an examination of the material collected.

From my notebook I find this sample, chocolate-coloured sandy clay with glauconite, was collected between the two ironstone bands on the west side of Hengistbury Head. No direct evidence could be gathered from the present series as to relationship with the Foraminifera of the Barton or Bracklesham Beds, from both of which formations I had collected on an extensive scale. The tests are all arenaceous, the facies representing a somewhat different hydrographic condition from that of the deposits belonging to the two last-named series, represented in my collection from the Barton Cliffs, Bracklesham Bay, and from many typical exposures in the Isle of Wight.

Description of the Foraminifera.

Fam. LITUOLIDÆ.

Genus Haplophragmium, Reuss.

Haplophragmium canariense, d'Orbigny, var. *pauperata*, nov. Figs. 1–4.

This variety is distinguished from the specific type[1] by its small and distorted condition, often accompanied by a deflation of the finely arenaceous walls of the chambers. The more regular examples, of which there are one or two exceptional cases, link themselves with *H. canariense*, of cosmopolitan distribution.

The variety is smaller than type-specimens of the species, the former averaging ·58 mm. in greatest diameter, whilst the latter measures ·84 mm. (*Challenger* example).

H. canariense, var. *pauperata* is moderately abundant in the washings from the clay seams of Hengistbury Head.

Genus Lituola, Lamarck.

Lituola simplex, Chapman. Figs. 7, 8.

Lituola simplex, Chapman, 1904, Rec. Geol. Surv. Vict., vol. i, pt. iii, p. 228, pl. xxii.

Several sub-discoid and crosier-shaped tests, very thin and compressed, and consequently very fragile, were found in the washings. They can be distinguished from mere adventitious flakes or concretions of mud by their simulation of the depauperated and compressed forms of *Haplophragmium* and *Trochammina*. Their obscurely septate and labyrinthic internal structures make them come within the Lituolid group.

The original examples above quoted were from similar washings of chocolate-coloured clays from the Miocene (Janjukian) of Brown's Creek, Otway Coast, Victoria. This particular fauna was remarkable for its shallow-water and estuarine character, although, strange to say, the genus *Cyclammina*, more or less depauperated, was also abundant therein. This latter genus was only recorded between 100 and 2,900 fathoms by the *Challenger*, and was then (in 1884) "unknown in the fossil state". Subsequently, however, *Cyclammina* has been noted from moderately shallow-water fossil deposits from the ? Jurassic onwards.[2]

The average diameter of the tests of *L. simplex*, as occurring in the present washings, is ·65 mm. The diameter of that figured from the Victorian Miocene is ·55 mm.

[1] *Nonionina canariense*, d'Orbigny, 1839, Foram. Canaries, p. 128, pl. ii, figs. 33, 34; *Haplophragmium canariense*, d'Orb., sp., Brady, 1884, Rep. Chall., vol. ix, p. 310, pl. xxxv, figs. 1–5.

[2] Rec. Geol. Surv. Vict., vol. i, pt. iii, p. 229, 1904.

Genus TROCHAMMINA, Parker & Jones.

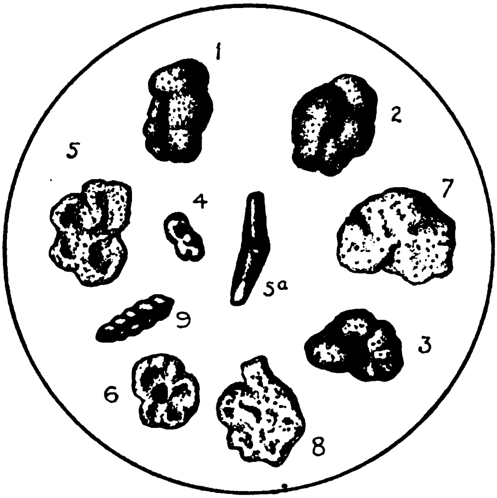
Trochammina inflata, Montagu, sp., var. *macrescens*, H. B. Brady. Figs. 5, 6.

Trochammina inflata, Montagu, sp., var. *macrescens*, Brady, 1870, Ann. Mag. Nat. Hist., ser. IV, vol. vi, p. 290, pl. xi, figs. *5a–c*.

This variety is even more emphasized in its emaciated condition than the specimens figured by Dr. Brady from tidal river deposits of the River Blythe, Northumberland, and the River Wear, 2 miles above Sunderland, although some examples from Hengistbury Head match it almost exactly excepting in the less open umbilicus.

In the recent and brackish mud deposits, as pointed out by Brady, the tests seem to show that the emaciated appearance is due to the falling in of the thin, chitinous, and sparsely arenaceous walls, from the contraction of the protoplasm in drying.

The specific form *T. inflata* is usually found in moderately shallow marine to brackish waters round the British coast.



FORAMINIFERA FROM THE EOCENE OF HENGISTBURY HEAD, HAMPSHIRE. × 25. Drawn by F. Chapman from nature.

FIGS.
1. *Haplophragmium canariense*, d'Orb., sp., var. *pauperata*, nov. Dorso-lateral aspect.
2. *H. canariense*, d'Orb., sp., var. *pauperata*, nov. Oral aspect.
3. ,, ,, ,, ,, ,, Lateral aspect.
4. ,, ,, ,, ,, ,, Micromorphic.
5. *Trochammina inflata*, Montagu, sp., var. *macrescens*, Brady. Lateral aspect. *5a*, oral aspect.
6. *T. inflata*, Montagu, sp., var. *macrescens*, Brady. Smaller example, lateral aspect.
7. *Lituola simplex*, Chapman. Lateral aspect.
8. ,, ,, Another example, lateral aspect.
9. *Virgulina subsquamosa*, Egger. Lateral aspect.

The largest example of the Hengistbury Head series has a diameter of ·6 mm., whilst the larger of Dr. Brady's figured examples from the English tidal rivers has a diameter of ·4 mm. This variety is exceedingly common in the washings.

Fam. TEXTULARIIDÆ.

Genus VIRGULINA, d'Orbigny.

Virgulina subsquamosa, Egger. Fig. 9.

Virgulina subsquamosa, Egger, 1857, Neues Jahrb. für Min., etc., p. 295, pl. xii, figs. 19–21; Brady, 1884, Rep. Chall., vol. ix, p. 415, pl. ii, figs. 7–11.

Foraminiferal tests allied to this form have already occurred in the estuarine deposits (Holocene) of the Fen-land in the East of England.[1]

Only one small example of this species was found, having a length of ·423 mm.

Note on the accompanying Ironstone Bed.—A thin slice of the ironstone of the Hengistbury Head Beds was examined under the microscope, with the following result:—

The general character is that of a fine-grained ironstone composed of excessively minute granules of carbonate of iron stained with peroxide of iron. Scattered throughout the rock and occasionally occurring in nests are minute angular fragments of quartz, such as are met with in the finest river silts. A few obscure stem-like fragments are also seen embedded. Under a high power the separate granules of carbonate of iron are seen to be covered with peculiar amber and ruddy-coloured articulations, probably representing the residual peroxide of iron after the change from the condition of bog-iron ore.

Conditions of Deposition.—Some interesting facts are brought out by the foregoing occurrence of the somewhat sparse and peculiar foraminiferal fauna of the Hengistbury Head clays. The forms are all arenaceous, showing a marked absence of calcareous rocks or calciferous waters in the neighbourhood. Such a fauna is generally found in the tidal estuarine areas of great rivers close to the coast and having a partially landlocked character. Similar deposits would occur, for example, on those parts of the Essex Flats at the present day, which are occasionally flooded at especially high tides, and where, in the boggy parts, saprophytic vegetation flourishes, capable of extracting the carbonate of iron from the surrounding water. The small dimensions of these Foraminifera, the poorly developed tests with shrunken chambers, and generally starved appearance point to their being a survival of a normal deep-water terrigenous facies, which has been pushed into uncongenial surroundings; for parallel types of all the forms here enumerated are well known in many of the green and blue muds of our deeper coastal deposits.

The question here arises, how came the glauconite grains in the clay deposit if the evidence of the Foraminifera points so strongly to estuarine conditions? for glauconite seems to be, so far as known, a material which is chemically deposited under marine conditions in

[1] Brady, loc. cit., p. 415.

moderately deep, not shallow water, and generally below the actual mud-line of the coastal margin.

From geological evidence derived from other sources it is quite reasonable to assume that these glauconite grains in the clays, which by the way are worn and otherwise ill-defined, have been derived from local, disintegrated and re-sorted, moderately deep-water deposits, such as are seen in the Barton and Bracklesham Beds themselves. In the Plateau Gravels of the London Basin, by way of illustration, glauconite grains are frequent; but no one would venture to assert that these granules were actually formed in the deposit, since much of the material in places was derived from the Lower Greensand ridges to the south.

The difficulty of accounting for the presence of mollusca and sharks' teeth in the closely associated sediments may be met in this way. A slight lowering of the estuarine series would convert the area into sandy and clayey submerged marine coastal plains, on which such genera as *Corbula*, *Tellina*, *Leda*, *Arca*, *Glycimeris*, *Anomia*, *Cardium*, and *Cardita* could flourish; whilst slightly deeper conditions would permit of the existence of genera like *Panopæa*. At the same time the fact of many of the mollusca found in this series being in the state of casts, shows that the sea-bottom at this period was in a state of oscillation rather than of equilibrium.

NOTICES OF MEMOIRS.

Trias and Carboniferous in the Caucasus.

Wittenburg, P. W. Recent Researches on the Trias of the Caucasus. (In Russian.) Bull. Acad. Imp. Sci. St. Petersburg, 1912, p. 433.

Robinson, W. N. Recent Researches on the Geological Structure of the Northern Caucasus in the Basins of the Rivers Bielaya and Laba. (In Russian.) Bull. Acad. Imp. Sci. St. Petersburg, 1913, p. 33.

Translated and abridged from the Russian by Felix Oswald, D.Sc., F.G.S.

THE discovery in 1907 of Upper Trias in the Kuban district of the Caucasus, which was described in the Geological Magazine (Dec. V, Vol. VI, No. 538, April, 1909, p. 171), has been considerably amplified and extended by the researches of P. W. Wittenburg, who explored the same district, viz. the upper courses of the Little Laba and Bielaya Rivers, and his results may be conveniently summarized in tabular form:—

1. *Rhætic Stage.*—(1) Typical *Avicula contorta* beds on Mt. Tkhach.

(2) Lower Rhætic is represented by grey crinoidal limestone interbedded with red marly limestone containing many Brachiopods, particularly masses of *Spirigera* belonging to the typically Rhætic group of *S. oxycolpos*, Emmr., and *S. Manzavinii*, Bittn. (Kössen Beds). It is well exposed in the Kun Valley near Mt. Tkhach, and

contains *Waldheimia cubanica*, Tschern., *W.* cf. *austriaca*, Zugm., *W. Bukowski*, Bittn., *Terebratula pyriformis*, Suess, *T. turcica*, Bittn., *Rhynchonella obtusifrons*, Suess, *Spirigera cubanica*, Tschern., *Retzia superbescens*, Bittn., *Amphiclina squamula*, Bittn., *Aulacothyris* cf. *Ioharensis*, Bittn., *Mysidioptera Gremblichi*, Bittn., *Pecten subalterni-costatus*, Bittn.

2. *Noric Stage.*—The facies of the Dachstein Limestone with *Megalodus* sp. of the group *Megalodus* (*Neomegalodon*) *triqueter*, Wulfen, was found on Mt. Yatyrgvart (also in the Kuban district), but this seemed to be a somewhat isolated occurrence. The red, compact limestones usually contain a rich coral fauna (not specified) with masses of *Pseudomonotis ochotica*, var. *densistriata*, Teller, which the author considers to be synonymous with *Ps.* (*Monotis*) *salinaria*, Bronn. They dip 10° N.W. by N. and are transgressive over 3.

3. *Carnic Stage.*—Black, thinly-bedded, micaceous slates, interbedded with grey sandstones, altogether about 75 metres thick. They contain *Koninckina Telleri*, Bittn., and badly preserved *Tropites*. In the lower horizon of this series, on the eastern slopes of Mt. Tkhach, thick beds of oysters occur.

4. *Ladinian.*—(1) Red, quartzitic sandstones, interbedded with black slates and marls, dipping 20° N.N.W., containing the characteristic Wengen fossils *Daonella Lommeli*, Wissm., and *Posidonomya wengensis*, Wissm., with siliceous sponges and plant-remains in the upper part. The best sections occurred in the Sokhra Valley.

(2) Conglomerate.

(3) 'Upper contorted series,' consisting of grey calcareous flagstones, well developed to the south-east of Mt. Tkhach, and containing a Cephalopod fauna (described by Professor Karl Diener). Owing to their poor preservation the fossils could only be generically determined as follows: "*Ptychites* sp ind. of the *Megalodiscus* group; gen. ind. sp. ind. of the Pinacoceratidæ family, recalling *Norites* or *Arthaberites*, but the condition of the suture-lines would permit of its being included in *Sageceras*; *Gymnites* sp. ind. aff. *incultus*, Beyr.; *Monophyllites* sp. ind. of the group *M. Suessi*, Mojs., closely resembling *M. Pitamaha*, Diener; *Monophyllites* n.sp.; gen. ind. sp. ind. of the Ceratitidæ family, recalling *Celtites* or *Monophyllites*; this specimen in all probability represents a new species near to *Nomismoceras spiratissimum*, Holzapfel; *Balatonites* sp. ind.; *Ceratites* sp. ind. belonging to the group of *C. circumplicatus*; *Orthoceras* sp. ind."

(4) 'Lower contorted series.' Much crushed and dislocated, dark siliceous limestones, showing a prevalent dip to north-west. A bed of limestone immediately overlying this strongly contorted series contains characteristic Werfen fossils (Scythian stage), e.g., *Cœlostylina werfensis*, Witt., *Terebratula* sp., *Gervillia exporrecta*, Leps., *Pseudomonotis venetiana*, Hauer, *P.* aff. *leptopleura*, Witt. This Scythian stage is widely distributed in the north-west Caucasus, e.g. in the valley of the Bielaya River near the confluence with its tributary the Dakh River, in many places in the Sokhra Valley (another tributary of the Bielaya), on Mt. Shavshin, and on the slopes of Mt. Tkhach.

The discovery by Messrs. Wittenburg and Robinson of these Werfen Beds in the Caucasus emphasizes the importance of the Caucasian Trias as a connecting-link between the Trias of the Alps and the Himalaya, for beds of this period have long been known to occur at Julfa in the Araxes Valley (which separates Russian Armenia from Persia), containing ***Meekoceras*** and species of ***Pseudomonotis***, which Bonnet (Bull. Soc. Géol. France, sér. 4, xii, 312) has shown to be allied to those of the ***Hedenstroemia*** beds of the Himalaya. The upper, unfossiliferous part of the Julfa Series, consisting of 200 metres of marly limestones overlain by 1,000 metres of black limestones and dolomites, is probably equivalent to the Middle and Upper Trias of the Caucasus.

Still more recently W. N. Robinson (op. cit.) in 1912 was able to establish the fact that the Triassic beds of the Caucasus overlie Upper Carboniferous limestones, as at Julfa. The locality is also in the basin of the Bielaya River, at Mt. Gepho on the left bank of the River Kisha (Choga), a right tributary of the Bielaya. Mt. Gepho rises to a height of 1,200 feet above the Tegen stream, which flows into the Kisha, and the natural section discloses the following downward succession :—

1. *Trias* (*Ladinian*).—(1) Grey, arenaceous flagstones with plant-remains and badly preserved fossils (not specified). Similar sandstones (dipping 70° N.E.) occur on the western spur of the Pshekish ridge. To the north-east the sandstones are dark red, very micaceous, and attain a considerable thickness.

(2) Conglomerate of small pebbles, mostly of quartz, but it varies considerably in thickness and materials; it extends nearly to the summit of Mt. Gepho and dips west. This conglomerate unconformably overlies the Carboniferous Limestone and is greatly developed along the northern slope of the Caucasus in the Kuban district. To the north-west it crops out in the Bielaya Valley, a little above Khamyshki (Alexievsk), and to the south-east as far as the Urups River and the upper course of the Zelenguk. Between the Bielaya and the Little Laba the conglomerate forms a large anticline and composes the ridges Pshekish and Bambak and the southern slope of the Mastakan ridge; it occurs also on the south-west side of the Dudugush ridge towards Mt. Oshten.

2. *Upper Carboniferous*.—(1) Grey limestones, forming rocky cliffs on both sides of the Tegen defile. They are so compact that the dip is scarcely visible, but in one place it seems to be southerly. They contain a rich Brachiopod fauna, e.g. ***Entetes contractus***, Gemm., ***E. carniolicus***, Schellw., ***Uncinulus velifer***, Gemm., ***Reticularia lineata***, Mart., ***Chonetes uralica***, Möll., ***Notothyris exilis***, Gemm., ***Richthofenia lawrenciana***, de Kon., ***Aulosteges***, ***Geyerella***, with Pelecypods, Gastropods, and sponges belonging to the families Sphærospongidæ (***Heterocœlia***) and Sphærocœlidæ (***Sollasia***, ***Steinmannia***).

(2) Black, argillaceous slates, forming the bed of the Tegen River, with intercalated, thinly laminated, black sandstones, dipping rather steeply to the south. They are extensively developed to the south-west, south, and south-east of Mt. Gepho, towards the main axis of the Caucasus. No fossils occur in the slates; but the interbedded

sandstones (in the Kozi Valley) contain a few undetermined Gastropods and Pelecypods.

The southerly dip of the slates is maintained over a wide area, and it is only on the south-west slope of the granite ridge Juga (Cheleps) that an anticlinal fold occurs with a steep dip to north-east. The axis of the anticline reveals crystalline schists, which form the bed of the Kisha River near Dokhmat Sheklan. This fold does not, however, extend far either to north-west or south-east. W. N. Robinson attributes the formation of this small fold to the intrusion of the granite.

The second outcrop of Upper Carboniferous was observed 2 miles S.S.W. of the confluence of the Little Laba and Urushten Rivers. The limestone is greyer than on Mt. Gepho, and forms an anticline; in its axis mica-schists and other crystalline schists are visible. To the south this Upper Carboniferous Limestone is overlain by conglomerate (probably Triassic), and higher up the Urushten River red Triassic limestones form vertical cliffs on both banks. The Upper Carboniferous Limestone contains the following fossils: *Spirifer cameratus*, Morton, *Reticularia lineata*, Mart., *Uncinulus velifer*, Gemm., *Productus gratiosus*, Waag., *P. pseudomedusa*, Tschern., Pelecypods (*Macrodon*, *Edmondia*, and *Lima*), and sponges (*Heterocœlia*).

Probably a large portion of the Palæozoic schists of the main axis of the Caucasus will be found to belong to the Carboniferous, and it may be mentioned that a crushed *Calamites* was found by Inostranzeff some years ago in the Central Caucasus to the north of the main axis.

REVIEWS.

I.—The Nature and Origin of Fiords. By Professor J. W. Gregory, D.Sc., F.R.S. 8vo; pp. xvi, 542, with 8 plates and 84 text-illustrations. London: John Murray, 1913. Price 16*s*. net.

THIS is a big book on a subject which, at first sight, seems hardly to justify such voluminous treatment; nevertheless, the author finds plenty to say. His travels have extended over wide areas of the globe, and he deals not only with the typical fiords of Norway, but with the fiords and other sea-inlets or drowned valleys, from Scotland, Greenland, and Alaska to Patagonia, Antarctica, and Australasia. Printed in bold type and well illustrated, the subject as expounded by Professor Gregory is of very great interest to geographer and geologist, and will doubtless be attractive to all travellers and students who seek to become acquainted with the origin of scenery. Apart from scenery, the author points out the influences of fiords since early times on navigation, the distribution of population, and the welfare generally of mankind.

We have been accustomed to look upon fiords, sea-lochs, and estuaries as for the most part drowned valleys excavated by rivers and in many cases also largely by glacial action, the resultant features being due to the effects of erosion on rocks of varying altitude, structure, and lithological character. Thus fiords occur among the hard rocky mountainous regions of Norway, and equivalent sea-lochs are found in similar regions in Scotland; broader rocky channels occur in less elevated grounds in some parts of Devon and Cornwall; and water-filled valleys with still gentler slopes characterize the coastal regions of Hampshire.

No question, however, arises with regard to submergence in connexion with these inlets. The problem is the origin of the main terrestrial features, which may have been due to quite different causes; hence a grouping of the sea-inlets is desirable, more especially as the terms gulf, bay, sound, loch, and firth, as the author points out, are loosely applied to different features. He would class the sea-drowned valleys into three main types: fiords, fiards, and rias.

A fiord is described as "a long inlet which extends far inland between steep opposing walls; it usually consists of long straight reaches, which turn and receive their tributaries at sharp and regular angles; and its walls are high, as fiords are restricted to mountain regions". Furthermore, there is "a rarity of bays and a scarcity of sites for human settlements" as there is little or no margin between wall and water, except small tracts at the head, or small deltas along the sides of the fiords. They are characteristic of dissected plateaus, and "streams flow gently across the uplands until they reach the fiord-wall and then plunge down in picturesque waterfalls".

Fiards "usually have no large rivers draining into them". They "are due to a lowland area with an irregular surface of hard rocks, having been partially submerged beneath the sea. The essential difference between fiards and fiords is that fiards are characteristic of coast-lands which rise but slightly above sea-level".

Rias are ordinary river estuaries, and the author adopts the Spanish term, as such drowned valleys are well represented in North-Western Spain. The rias and fiards are alike "in having curved lines, gentle slopes, and indented shores". It is admitted, however, that it is difficult to establish sharp distinctions between fiords and other arms of the sea; fiords pass gradually into fiards and rias, the changes being due to modified conditions, such as increased submergence.

It is pointed out that most fiords occur in the more northern and southern areas of the globe, that they are in fact best developed in regions that have been subjected to glacial action. Hence it is not surprising that the excavation of the deep valleys has been attributed to glacial action.

The personal observations of Professor Gregory, fortified by a study of the writings of those who have examined special areas in detail, have led him to conclude that while "fiords are clearly valleys, of which the lower ends have been drowned by the sea", nevertheless "all the fiord-systems of the world owe their characteristic features to earth-movements, and not to glacial action". Moreover, "river-action will not produce fiords." It must be borne in mind that the deepest fiord, in Patagonia, is 4,250 feet, and that the Sogne fiord in Norway descends to nearly 4,000 feet, with bordering walls 3,000 to 4,000 feet high.

There is no doubt that many fiords were once occupied by ice, and that much shattered and weathered rocky material was then cleared away so as to enlarge the valleys. It is contended that the plans of fiords and sea-lochs cannot be explained by glacial erosion, partly because "the course of the fiords is inconsistent with the lines of flow of the chief glaciers" or ice-sheets; but here the effects of the local glaciers may have been subsequently checked by the invasion of the more extensive sheets of ice. Fiords, however, are not limited to areas that have been glaciated, and they are not always found in regions where, if due mainly to ice-action, they should be expected.

With regard to river-action, it is pointed out that fiords are not the outlets of the main rivers, that in fact "their existence depends on the absence of large rivers, which would fill them with sediment and give them the form of ordinary valleys by wearing their walls into long, gradual slopes". Here, of course, the geological structure and physical features are largely responsible, as in the case of much of the Western Highland area, where the steep slopes and rapid drainage prevent the formation of large rivers.

The plan of the chief fiord systems of the world is stated by Professor Gregory to be essentially the same. Fiords occur in trough-shaped valleys that are arranged along a kind of angular network caused by intersecting lines of fracture. This structure was produced by the uplift of the areas to form plateaus: disturbances begun in Miocene but carried out mainly in Pliocene times. The areas of hard rocks were then more or less shattered and cleft by cracks, and subsidence took place of belts of country along the fissured grounds, the troughs or deep basins being formed by irregular movements in Pre-Glacial times. The author refers much excavation to the Pliocene period. In any case, if erosion were commenced so early, it was continued during Pleistocene times by glaciers and other agents.

Here it may be mentioned that in referring to Plymouth Sound, Mr. Clement Reid has remarked that its rocky floor shows a depression far greater than we meet with in ordinary Pleistocene valleys, and "represents not improbably a Tertiary basin".[1] Mr. J. B. Hill also, as quoted by Professor Gregory, has remarked concerning certain valleys and inlets of Southern Cornwall that "the straightness of some of them, and in other cases their parallelism, suggests that their course has frequently been determined by lines of dislocation or well-marked joints". Dr. Nansen might also have been called as a witness to the influence of earth-movements in Norway. He has stated that "the longitudinal valleys and fiords of the land surface as well as of the sea-bottom outside, indicate a system of ancient folds and perhaps faults, possibly formed simultaneously with the uplift of the northern Norwegian mountain chain, or the original subsidence of the bottom of the sea-basin outside".[2] Earlier observations, however, by Kjerulf, and the more recent researches of Dr. Sederholm and of others, receive full consideration, and the main features of the Norwegian fiords are illustrated in admirable photographs by Mr. H. W. Monckton.

[1] *Submerged Forests*, 1913, p. 84.

[2] *Norwegian N. Polar Expedition 1893–1896*, *Scientific Results*, vol. iv, p. 56, 1904.

Particulars are given of the fiards of Sweden, the sea-lochs and freshwater lochs of Scotland, and of drowned valleys in regions too numerous to mention. Cañons, rock-basins, and various problems of glacial erosion are also discussed, so that the author has supplied much material of profound geological interest, and much in support of his contention that fiords owe their main features to earth-movements.

II.—(1) THE MINERAL KINGDOM. By Dr. REINHARD BRAUNS, Professor of Mineralogy in the University of Bonn. Translated, with additions, by L. J. SPENCER, M.A., F.G.S., Mineral Department of the British Museum. 4to; in 25 parts, pp. 432, with 91 plates (73 of which are coloured) and 275 text-figures. Stuttgart, Fritz Lehmann and afterwards J. F. Schreiber; London, Williams & Norgate; 1908–12. Price 2*s*. per part and £2 16*s*. for the bound volume.

(2) THE WORLD'S MINERALS. By LEONARD J. SPENCER, M.A., F.G.S. (editor of the *Mineralogical Magazine*), Mineral Department, British Museum. 8vo; pp. 212, with 40 coloured plates and 21 diagrams. London and Edinburgh: W. & R. Chambers, Ltd., 1911. Price 3*s*. 9*d*.; American edition $2.00.

TWO works on mineralogy have recently appeared, both bearing the name of L. J. Spencer, M.A., F.G.S., upon their title-pages. For the smaller of these volumes, *The World's Minerals*, Mr. Spencer is alone responsible. But the larger work, *The Mineral Kingdom*, published in quarto form in twenty-five parts, now completed, is an English version of Dr. Reinhard Brauns's *Mineralreich*, translated, with additions, by Mr. Spencer. These two names standing together upon the title-page suffice to vouch for the excellence of the volume.

A former work by Dr. M. Bauer, *Edelsteinkunde*, 1896, also translated by Mr. Spencer, *Precious Stones*, 1904, having been now for some years in the hands of English students, has become a standard book for those who work in precious stones.

The Mineral Kingdom contains ninety-one plates, seventy-three being coloured; these give excellent representations of the various minerals. It seems almost a pity, from the artistic standpoint, to heighten the coloured figures of metallic ores by gilding and silvering, when such beautiful results are obtained by the modern photographic reproductions without gilding, although it is certainly very skilfully introduced in this work. The plates will be of great practical value, particularly to those workers whose opportunities do not enable them to consult actual specimens in public collections. In addition there are 275 figures in the text which greatly increase the value and utility of the book to any one whose work or pursuits bring them in touch with some branch of mineralogy. It is interestingly written, and the explanations are clear and easy to understand. In addition to a full description of each mineral species, the dates of their discovery, methods of identification, testing, and working, economic uses and geographical distribution, all find a place in these pages.

The classification of minerals is somewhat unusual, *The Mineral Kingdom* being divided into four great parts. The first of these includes all metallic ores and their associates. Under this head minerals which have a special interest for the miner are described, commencing with gold. After first giving a short archæological account of the precious metal, the authors then proceed to deal with its mode of occurrence, methods of testing, geographical distribution, etc. Platinum is next dealt with, then silver, copper, mercury, lead, zinc, antimony, bismuth, arsenic, sulphur, iron, manganese, nickel, cobalt, tungsten, molybdenum, uranium, tin, and titanium. There is also a short appendix dealing with meteoric irons and stones.

Precious stones and related minerals is the next heading. This section comprises all the minerals with which the jeweller is concerned, from the diamond to 'common quartz'. These, which were fully dealt with from that standpoint in *Edelsteinkunde*, are here described from their mineralogical aspect chiefly, although methods of cutting, historical, and other points of interest are touched upon.

Part iii consists of rock-forming silicates and allied minerals. This section, apart from its purely scientific side, is one which is of interest to architects and workers in stone. Here the preparation of suitable sections for microscopic study of rock-structure is explained, and the various rock-forming minerals are described.

The last class is entitled 'mineral salts'. Several mineral substances of great commercial value are dealt with under this heading, but it also includes that group so attractive to the amateur, the fluorspars.

In *The World's Minerals* Mr. Spencer gives short descriptions of the minerals figured. The forty plates are also coloured, which is a great help to the inexperienced collector, to whom this book should prove most acceptable. The plates do not equal those in the larger work, and space of course does not allow of much more than one figure for each of the 116 mineral species described; in some cases the student would be glad of more illustrations to aid in identification. The introductory chapters are helpful and simply expressed, giving a short explanation of crystallographic systems, the physical characters of minerals, and their chemical composition and classification.

III.—Physiography.

The Realm of Nature; an Outline of Physiography. By H. R. Mill, D.Sc., LL.D. Second edition. 8vo; pp. xii, 404, with 19 coloured maps and 73 figures in text. London: Murray, 1913. Price 5*s*. net.

THE usefulness and popularity of the first edition of this book is evident from the fact that it has been reprinted no less than six times since its appearance in 1891. This edition has been thoroughly revised page by page, and can be justly recommended to the reader. The author sets forth to illustrate the principles of science by applying them to the world we live in, and to explain the methods by which our knowledge of Nature has been acquired and is being daily enlarged. The greater part of the book is occupied by an outline of the more important facts regarding the structure of the universe, the form, material, and processes of the earth, and the relations which they bear to life in its varied phases.

The headings of the chapters run as follows: Study of Nature; Substance of Nature; Energy, the Power of Nature; the Earth a Spinning Ball; the Earth a Planet; Solar System; Atmosphere, its Phenomena; Climates; Weather and Storms; Hydrosphere; Ocean Bed; Crust of Earth; Action of Water; Record of the Rocks; Continental Area; Life; Man. The maps are clearly printed and valuable, and show magnetic conditions, earthquake regions and volcanoes, isotherms, isobars, winds, rainfall, salinity of oceans, configuration of globe and coastal lines, drainage areas, evolution of continents, ocean-surface isotherms, coral reefs, rising and sinking coasts, vegetation zones, and biological regions.

It is one of those handy volumes the usefulness of which becomes daily more apparent, and the price greatly assists its recommendation. It has an index, but the worker will add to this for his own convenience such words as maelstrom, dunes, travertine, stalagmite, stalactite, metric system, zero, rigidity, atomic weight, lodestone, etc., which to publishers do not seem to be of any importance.

IV.—The Nickel Industry: with special reference to the Sudbury Region, Ontario. By A. P. Coleman, Ph.D., F.R.S. Department of Mines, Canada, No. 170, pp. vii + 206, with 14 text-figures, 63 plates, and 8 coloured maps. Ottawa, 1913.

During recent years the Canadian Department of Mines has issued several useful monographs on various minerals of economic importance which occur and are mined in the Dominion, and the present volume adds another to this series. The group of mines near Sudbury produces two-thirds of the world's supply of nickel, the amount for the year 1910 being 18,636 tons of metal, together with 9,630 tons of copper, of a total value of rather over one million pounds sterling. The ore here consists of an intimate mixture of pyrrhotite (magnetic pyrites), pentlandite (a sulphide of iron and nickel), and copper-pyrites, more or less intermingled with rock-forming silicates. It occurs at the base of an intrusive sheet or huge laccolite of igneous rock, and it passes imperceptibly into this. This sheet, consisting of norite in its lower portion and graduating upwards into micropegmatite, is intrusive between the crystalline rocks of the Laurentian and the sedimentary rocks of the Upper Huronian. Its outcrop forms the rim of an oval basin measuring 36 miles along the major axis and 16 miles across, and the several mines in which the nickel ore is worked are situated along the rim of this basin. We have here clear evidence of magmatic differentiation on an enormous scale; the acid rock passing downwards into basic rock, whilst at the bottom of all are the heavy metallic sulphides.

An outline of the physiography and general geology of the district and a mineralogical description of the ores is followed by an historical sketch of the mining industry, and detailed particulars relating to each of the several mines now working. Although the occurrence of nickel in this district was first recorded in 1856, it was not until 1884, when large bodies of ore were exposed in the cuttings of the

Canadian Pacific Railway, that mining operations were commenced. Curiously, however, the mines were first worked for copper (the principal nickel-producing firm still being the Canadian Copper Company), but it was soon found that the presence of nickel interfered with the extraction of the copper; and, indeed, it was not until about that time that nickel came to have any commercial value. Detailed descriptions are also given of the methods of mining, of the mechanical treatment of the ores, and of the metallurgical processes. The occurrence and treatment of nickel ores in other parts of the world, principally in New Caledonia and Norway, are also dealt with. Finally, there is a short account of the uses of nickel in coinage (though not in Canada), but particularly in nickel-steel and other alloys. No mention is, however, here made of the extensive use of nickel salts in electroplating.

V.—Professor Doelter's Mineralogy.

Handbuch der Mineralchemie. By Hofrat Prof. Dr. C. Doelter. Bd. III, i, pp. 1–160. 8vo. Steinkopf: Dresden and Leipzig. Price 6.50 marks.

THE first part of the third volume of this work deals with the oxides of titanium, zirconium, niobium, tantalum, and their compounds with silica. The quantitative separations and estimations of these oxides present many problems of grave difficulty to the chemist. The various methods in use are described and discussed by Dr. K. Peters, in addition to which there are special articles on the analysis of låvenite, eudialyte, johnstrupite, and catapleite by Dr. R. Mauzelius, and on the analysis of euxenite by Dr. G. T. Prior. Dr. R. Pribram contributes a section on the chemistry of germanium and the minerals in which it occurs.

A very interesting chemical problem is the composition of the rare mineral strüverite, which Dr. Prior has shown to be isomorphous with ilmeno-rutile: both minerals are regarded as solid solutions of tapiolite or mossite (iron tantalate and niobate) in rutile. It is suggested that the name strüverite be reserved for those members of the series in which tantalic acid preponderates over niobic acid, those richer in the latter being called ilmeno-rutile. The determination of both tantalum and niobium in the presence of large amounts of titanium thus becomes a problem of great importance: this problem has now been successfully solved by Hess and Wells in America and more recently by S. J. Johnstone in London.

Another group of minerals of great interest are the three forms of titanium dioxide; rutile, anatase, and brookite. To account for the existence of these three forms many theories have been advanced; these theories still await definite proof, for while recent analyses of rutile are fairly abundant, only two analyses of anatase and brookite appear to have been made within the last fifteen years. The brookite analysed by Rose in 1844 and said to have come from Snowdon, Wales, was doubtless from the well-known locality for that mineral near Tremadoc.

Professor Doelter himself has contributed very largely to this part in articles on special minerals, perhaps the most important being the section dealing with zircon. Some varieties of this mineral show considerable departures from the usual formula, $ZrO_2 . SiO_2$; artificial crystals of the composition $3 ZrO_2 . 2 SiO_2$ have been prepared, and it is suggested that some such isomorphous mixtures may occur in nature. The variations in density and refractive indices of zircons, and the effect of heat, light, and radium on stones of various colours are discussed. Zircons can be divided roughly into two classes, red and brown stones on the one hand and green stones on the other. The green stones are usually less dense and have lower refractive indices than the brown ones, and at present no satisfactory explanation of these differences has been reached. As regards the colour, Professor Doelter and others have shown that the brown stones are decolorized when strongly heated, the colour returning under the influence of radium emanations, but both heat and radium are without appreciable effect on the green zircons. The inference drawn from these facts is that the brown colour is due to a radio-active constituent of the zircons, while the green stones owe their colour to some more stable substance.

VI.—Geology in the Congo.

Annales de la Société géologique de Belgique. Publications relatives au Congo Belge, 1912–13, pp. 75–125.

THE Geological Society of Belgium are to be congratulated on the work which their members are doing in the Congo, and which they are now publishing in an appendix to the annals of the Society. The second part of this special publication contains details of a boring passing through 80 metres of the Lualaba Series, observations on the lower part of the Lubilache Beds, and a second series of M. Buttgenbach's contributions to the petrology of the district.

M. Mercenier, working in the neighbourhood of Albertville on the west of Lake Tanganyika, has traced a series of great faults running approximately parallel to the Tanganyika depression. M. Cornet has previously demonstrated the existence farther to the west of another great depression some 200 kilometres in length, which he has called the Upemba "graben". In a preliminary note by M. Delhaye on the Katanga district we find evidence of yet another great series of trough-faults causing the depression of the Lufira River. M. Mathieu, in a paper on the hot springs of Lower Katanga, shows that the distribution and characters of these springs bear a relation to the areas of depression. He records the temperature and mineral composition of these springs throughout the area, and shows that these characters are closely related to their distribution. Thus the hot springs of the Tanganyika depression have a temperature of 40–55° F., are highly charged with chlorides, sulphates, and soda, and contain relatively little carbonate: those of the Upemba depression, on the other hand, have a temperature of 70–100° F., are not highly mineralized, and carbonates preponderate over chlorides and sulphates. Springs of the first group appear to be connected with eruptive rocks; those of the second group occur mainly at contacts of the quartzites with granitic rocks.

VII.—Brief Notices.

1. On the Skeleton of *Ornithodesmus latidens*: an Ornithosaur from the Wealden Shales of Atherfield, Isle of Wight. By R. W. Hooley. Quart. Journ. Geol. Soc., vol. lxix, pp. 372–422, pls. xxxvi–xl, 1913.

In this important paper Mr. Hooley gives a very complete description of a new species of Pterodactyl, founded mainly on a remarkable specimen in which the bones are most perfectly preserved and quite uncrushed. The author was able to remove the very hard matrix to such an extent that he could find by actual trial the natural motions of the bones on one another, and in this way to study the mechanics of the reptile's wings. The type is a very remarkable one and of great interest, because it represents an extremely large animal, spread of wing about 5 metres, belonging to quite a different group from the other well-known large types, the toothless *Ornithostoma* of the Kansas Chalk. The paper concludes with a discussion of some points in the structure of Pterodactyls and of their classification in the light of this new type.

2. Rekonstruktionen des Flugsauriers, *Rhamphorhynchus Gemmingi*, H. v. M. By Ernst Stromer, of Munich. Neues Jahrbuch für Min. Geol. u. Pal., January, 1913, Bd. ii, S. 49–68, Taf. iii–v.

An important paper, dealing with many points in the osteology of Pterodactyls, illustrated by a beautiful drawing of a restoration of the skeleton, and photographs of a remarkable life-size model of the skeleton from three aspects, which give a much better idea of the build of a long-tailed Ornithosaur than has previously been possible.

3. On some New Genera and Species of Dicynodont Reptiles, with Notes on a few others. By R. Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxvi, pp. 441–57.

A description of three new genera and thirteen new species of Dicynodont reptiles. The specific and generic characters are mostly drawn from the features of the top of the skull in the pineal region, particularly from the relations of the pre-parietal, which are illustrated by clear figures.

4. Note on *Equus capensis*, Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxv, pp. 437–9.

A description of upper premolar (pm.^{4}) of the large *E. capensis*, which is found associated with the extinct *Bos baini*, *Connochætes antiquus*, *Colus venteræ*, and human implements.

5. On Evidence of a Mammal-like Dental Succession in the Cynodont Reptiles. By R. Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxviii, pp. 465–8.

Dr. Broom describes a specimen which appears to give satisfactory evidence of the replacement of canines, incisors, and milk molars in *Diademodon*, a discovery of very great importance, as hitherto, although examples of Therocephalia, Gorgonopsids, and Cynodonts showing replacements of the canine have been fairly common, and specimens showing replacements of the incisors known, none have shown any replacement of cheek-teeth, a fact which has told somewhat against the relation of these types to mammals. It now seems probable that the group will show us all the stages, from the indefinite replacement of teeth in the ordinary reptilia to a very definite replacement similar to that occurring in mammals. The specimen is perhaps not absolutely conclusive, but affords very considerable reasons for believing that Dr. Broom's interpretation is correct.

6. ON THE ORIGIN OF THE CHEIROPTERYGIUM. By R. BROOM. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxvii, pp. 459–64.

A description of the well-known fin of *Sauripterus taylori*, and the suggestion that the Tetrapod limb may have been derived from such a fin by the development of some of the pre-axial skeletal elements and the loss of the post-axial, which continued to support the fin during the change.

7. THE SKULL ELEMENTS OF THE PERMIAN TETRAPODA IN THE AMERICAN MUSEUM OF NATURAL HISTORY, New York. By F. v. HUENE, Tübingen.

In this large paper the author gives short descriptions and figures of many of the types of reptiles found in the 'Permian' of Texas. This paper is important in that it contains the views and criticisms of a distinguished and independent author on many of the disputed facts of structure of these very interesting forms. Dr. v. Huene not only adds to our knowledge by determining many new sutures, but also by redetermining some of the bones figured by Case. The author adds some interesting discussion on morphological points and on taxonomy.

8. THE TEGELEN BEAR.—Mr. E. T. Newton has described under the name of *Ursus etruscus* (= *U. arvernensis*) a number of teeth from the Pliocene clay of Tegelen-sur-Meuse (Geological Proceedings for Netherlands and Colonies, 's Gravenhage, 1913). He remarks that "At present *U. etruscus* is only known from Pliocene deposits of Europe; but there are indications of somewhat similar fossil forms occurring in India and China, and it may well be that from these Pliocene species the modern Black Bears are descended which to-day are found widely distributed in America and Asia".

9. MR. CHESTER G. GILBERT and Mr. Joseph E. Pogue contribute to the Proceedings of the United States National Museum, vol. xlv, 1913, a paper on "The Mount Lyell Copper District of Tasmania", in which they gave a succinct account of the geology and mode of working the famous copper-mines. The paper, which is the outcome of a study of a representative collection of rocks received in 1910 by the museum from Mr. Robert Slicht, manager of the Mount Lyell Mining and Railway Co., is largely based upon Professor J. W. Gregory's well-known memoir.

10. IN the Bulletin de la Société Belge de Géologie, vol. xxvii, 1913, M. A. Ledoux gives the results of an elaborate study of quartz crystals from Belgium, and records altogether eighty-one forms. Twins are very common, and, indeed, etching figures show that

simple individuals are rare. Groups of crossed crystals are often met with which are not true twins. The various occurrences—in eruptive rocks, metalliferous veins, quartz veins, and sedimentary rocks—are described in detail. The paper is amply illustrated.

11. Fluting and Pitting of Granites.—An interesting and well-illustrated article on this subject, by Mr. J. C. Branner, has been published by the American Philosophical Society (Proc. lii, April, 1913). The fluting of granites and other crystalline rocks appears to be confined to tropical and possibly sub-tropical countries. Striking examples are seen near Quixadá, in Ceará State, Brazil, mostly in massive coarse-grained gneissoid granodiorites. The furrows start at or near the summit of the exposed rock, and run straight down the rock-slopes by the shortest possible routes. Some reach a depth of nearly 2 metres measured at right angles to the general surface of the rock-masses. In the same region the fluted rocks have been hollowed into "great rounded caldron-like pits, some of which are associated directly or indirectly with the fluting". These pits seldom exceed 2 metres in depth and their diameter is about 2 metres. In certain cases they occur in a nearly vertical row, connected by a furrow, and having the appearance of a great irregular staircase mounting the hill. The fluting seems to occur only on steep slopes, with an angle of 45° or more, and it is caused by the rainfall, small in amount, that acts in part chemically, in part mechanically. The pits are formed by the disintegration and dissolution of minerals.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 5, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communication was read:—

"Geological Sections through the Andes of Peru and Bolivia." By James Archibald Douglas, M.A., B.Sc., F.G.S.

This paper deals with the geological structure of the South American Andes, as illustrated by a horizontal section drawn from the port of Arica in the extreme north of Chile (formerly Peruvian territory) across the mountain-ranges or 'Cordilleras' to the forested region of the Amazon slopes, in the district known as the Bolivian 'Yungas', following the route of the new Arica–La Paz railway, which was under course of construction at the time of the author's visit.

It is the partial result of two years' geological exploration in Peru, undertaken on behalf of Mr. W. E. Balston, F.G.S., for the Oxford University Museum. After a description of the general physiography of the Peruvian Andes, the topographical features of the country traversed by the railway are discussed in some detail.

Its geological structure is then described under three headings: (1) The Mesozoic sediments of the coastal region with their contemporaneous igneous rocks, the intruded core of granodiorite, and the overlying recent volcanic rocks of the Western Cordillera. (2) The volcanic rocks of the Mauri River, the Mesozoic and Palæozoic sediments of the 'Altaplanicie' and the Titicaca district; the line of dioritic intrusions, and the Pleistocene gravels of the Desaguadero River. (3) The Palæozoic rocks and granitic core of the Eastern Cordillera and the Amazon slopes.

(1) The Mesozoic stratified rocks are well exposed in the 'Morro de Arica', where fossils occur which indicate an Upper Jurassic (Callovian) age. They are interbedded with thick sheets of basic enstatite-andesite, showing well-marked 'pillow'-structure; this rock is remarkably fresh, and free from albitization.

Similar stratified rocks are traced up the Llutah and Palca river-valleys. In the former they are penetrated by a thick intrusion of quartz-hypersthene-norite, which, it is suggested, is the plutonic equivalent of the pillow-lava of the coast.

The erosion of the river-valleys that has brought to light the Jurassic sediments has also laid bare the underlying plutonic mass of granodiorite, which may be regarded as the deep-seated core of the Western 'Cordillera'. This plutonic mass appears to have been intruded in the form of a batholite in post-Cretaceous times.

The Western Cordillera is essentially a volcanic range, formed of numerous more or less isolated, snow-capped, dormant, and extinct volcanoes, attaining heights of 19,000 to 20,000 feet. The enormous amount of volcanic material emitted from these cones has almost completely concealed the underlying rocks.

The lavas can be resolved into three main groups, characterized by their dominant ferromagnesian mineral, succeeding one another in age according to a law of increasing basicity: (*a*) acid rhyolites and tuffs with biotite; (*b*) trachytes and trachy-andesites with hornblende, typically developed in the district of Mount Taapaca; (*c*) andesites and basalts with pyroxenes, forming the cones of Mounts Tacora and Chupiquiña.

(2) The western part of the high-level Bolivian plateau, or 'Altaplanicie', is almost entirely covered by vast horizontal sheets of volcanic ash, tuff, and pumiceous lava, described as the Mauri Volcanic Series. These rocks have often the appearance of 'trass', and it is suggested that they have been formed in large part as subaqueous deposits. The occurrence in an interbedded layer of gravel of a fragment of a jaw of '*Nesodon*', almost identical in appearance with specimens from the Miocene beds of Santa Cruz, affords the only clue for an estimation of their age. They are overlain on the east by gravel deposits of the Desaguadero River, the highest terrace of which was found to contain remains of ***Mastodon***, ***Megatherium***, ***Scelidotherium***, and other Pleistocene vertebrates.

From beneath these superficial deposits crops out a series of unfossiliferous red and chocolate-coloured sandstones and conglomerates. After comparison with other districts on the north, these are divided into two groups—a younger gypsiferous sandstone and marl series of Cretaceous age, broken through by a line of dioritic intrusions and resting with pseudoconformity on an older Permo-Carboniferous group. The latter ends abruptly along a fault-line against vertical shales and quartzites, containing a few characteristic Lower Devonian fossils. These Devonian beds, though much concealed by alluvial plains, form the basement of the eastern part of the 'Altaplanicie'.

The Carboniferous formation is nowhere exposed along the line of section, but an account is given of its development in the region of Lake Titicaca, where the limestones contain an Upper Carboniferous or Permo-Carboniferous marine fauna.

A short discussion is entered into on the theory of the recent elevation of the Andes and the origin of Lake Titicaca.

(3) The Eastern Cordillera rises to heights of over 22,000 feet, being composed chiefly of steeply dipping Devonian slates and quartzites, though many of the unfossiliferous black slates and greywackes of the eastern slopes most probably may be referred to the Silurian, or even to an older formation. Outcrops of granite are of rare occurrence along the line of section, although there is reason to suppose that this rock forms the core of most of the high peaks. As marine Lower Carboniferous and Upper Devonian rocks are absent from this district, it is suggested that the granitic core was intruded during a period of land-elevation at this time.

II.—Zoological Society of London.

October 28, 1913.—Professor E. A. Minchin, M.A., F.R.S., F.Z.S., Vice-President, in the Chair.

1. Dr. F. A. Bather, M.A., F.R.S., F.Z.S., read a paper entitled "The Fossil Crinoids referred to *Hypocrinus*, Beyrich". The two specimens of *Hypocrinus schneideri*, Beyr., described by Beyrich and Rothpletz respectively, are redescribed and refigured. The structure of the genus is shown to agree with that of the Devonian family Gasterocomidæ, the content of which is discussed; but it is suggested that in this case and in that of '*Lecythiocrinus*' *adamsi* the distinctive features may have been independently acquired.

The holotype of *Hypocrinus piriformis*, Rothpletz, is redescribed and refigured, and proved to be no *Hypocrinus*. It is thought to be a highly modified descendant of the Taxocrinidæ, by way of such a genus as *Cydonocrinus*. The left posterior radial appears to have borne a large arm, but the other arms are more or less atrophied, and the right posterior radial has almost disappeared.

2. A paper on "*Batrachiderpeton lineatum*, Hancock & Atthey, a Coal-measure Stegocephalian", communicated by Professor J. P. Hill, D.Sc., F.R.S., F.Z.S., was read by Mr. D. M. S. Watson, M.Sc. It contained the description of the skull, lower jaw, and pectoral girdle of this species, based on a series of specimens in the Newcastle Museum, derived from the Low Main Seam of Newsham Colliery.

3. A paper, communicated by Dr. C. W. Andrews, F.R.S., F.Z.S., was received from Mr. R. W. Palmer, M.Sc., entitled "The Brain and Brain-case of a Fossil Ungulate of the genus *Anoplotherium*", in which a cranium from the Phosphorites of Quercy, together with an exceptionally perfect and well-marked brain-cast obtained from it, were described from material in the British Museum collections.

OBITUARY.

HENRY FRANKLIN PARSONS, M.D., F.G.S.

BORN FEBRUARY 27, 1846. DIED OCTOBER 29, 1913.

WE much regret to record the death, at the age of 67, of Dr. Franklin Parsons, F.G.S., a medical officer who was distinguished for his extensive knowledge and wide experience of sanitary science, who was an enthusiastic worker in geology, and an expert botanist.

He was born at Beckington, a village about 3 miles north-east of Frome in Somerset, and was the eldest son of Joshua Parsons, a surgeon, who took much interest in the natural history of the district. The geological features are extremely varied, as within a walking distance of Beckington there can be studied the Old Red Sandstone and Carboniferous rocks, the Trias, Lias, most of the Oolitic rocks, and Upper Cretaceous strata. After education in private schools Franklin Parsons proceeded to St. Mary's Hospital, and subsequently took high honours in medical subjects at the University of London, with the degree of M.D. in 1870. From 1867–73 he was engaged in medical practice with his father at Beckington, and devoted most of his leisure to the study of geology and botany. Some of his observations were communicated later on to the Somersetshire Archæological and Natural History Society in a paper on "The Flora of East Somerset" (1875), wherein he pointed out the relations between the geology and the distribution of the plants, and in another paper on the "Geology of the District around Bruton" (1879).

In 1874 Dr. Parsons was appointed Medical Officer of Health for the combined districts of Goole and Selby, in Yorkshire. Here he turned his attention to local natural history, to the warp of the Humber and its diatoms, the results being given to the Geological Society of the West Riding in papers on "The Maritime Plants and Tidal Rivers" (1876), and on "The Alluvial Strata of the Lower Ouse Valley" (1878). To the same Society he also communicated a paper on "The Trias of the Southern Part of the Vale of York" (1879).

Dr. Parsons was married in 1879 to the daughter of the late John Wells, J.P., of Booth Ferry House, Yorkshire, and the same year was appointed a Medical Inspector on the Local Government Board. In this department he was frequently engaged on sanitary questions in which his knowledge of geology was of great practical service, as in connexion with sites for cemeteries and sewage-farms, with water-supply, pollution, and sundry epidemics. He prepared a "Memorandum on the Sanitary Requirements of Cemeteries", which was issued by the Local Government Board in 1880 and revised in 1906. In 1892 he became Assistant Medical Officer, being second in command on the Medical Staff of the Board, and this post, which included that of Inspector for General Sanitary Purposes, he held until his retirement early in 1911. Among his many official publications it will be appropriate here to mention his "Report on Geological Considerations in relation to Public Health and Sanitary Administration" (30th Ann. Rep. Loc. Gov. Board for 1900–1, 1902, p. 258). When President of the Epidemiological Society he delivered addresses on "Half a Century of Sanitary Progress and its Results" and "On the Comparative Mortality of English Districts". As remarked in the *Lancet* (November 8, 1913, p. 1356), "he probably influenced the sanitary development of this country more than anyone else." He was Examiner in Hygiene and State Medicine for the University of London, and for the diploma of Public Health at Cambridge. He likewise served on various departmental committees, including the annual Consultatory Committee on the Geological Survey, under the Board of Education. To the Geological Survey he rendered much assistance in the matter of water supply, and his name appears on the title-page of memoirs dealing with the wells and borings in Lincolnshire, Suffolk, Kent, and Sussex (supplement). Dr. Parsons became a Fellow of the Geological Society in 1877, and a member of the Geologists' Association in 1911. He was an active member of the Croydon Natural History and Scientific Society, usually exhibiting at the meetings of the Geological Section some of the fossils which he had collected. As President for the year 1912 he delivered (on January 21 of this year) an address on "Plant Growth and Soil Conditions". H. B. W.

PROFESSOR DR. ANTON FRITSCH.

We regret to record the death of our old friend Professor Dr. Anton Fritsch, Director of the Royal Bohemian Natural History Museum, Prague, which took place on the morning of November 15. Dr. Fritsch had attained his 82nd year, and we hope to give some account of his long scientific career next month.

MISCELLANEOUS.

Appointment of New Director to the Geological Survey and Museum.—The President of the Board of Education has appointed Dr. Aubrey Strahan, F.R.S., to be Director of the Geological Survey of Great Britain and Museum of Practical Geology, in succession to Dr. J. J. H. Teall, F.R.S., who will retire from the post on January 5 next. Dr. Strahan, who was born in 1852, was educated at Eton and St. John's College, Cambridge. He was elected a Fellow of the Royal Society in 1903, and is President of the Geological Society. He is the Assistant Director of the Geological Survey of England and Wales.

Dr. Teall, who was born on January 5, 1849, has been Director of the Geological Survey and Museum since 1901. He is the author of *British Petrography, a Description of the Rocks of the British Isles*, 1888.

Kent Coal-field.—Dr. Malcolm Burr has tabulated and printed in the *Colliery Guardian* for October 10, 1913, the available information as to the strata revealed by the borings at Tilmanstone, Guildford, Oxney, Maydensole, Ripple, Barfrestone, Goodnestone, Trapham, Woodnesborough, Stodmarsh, Walmestone, and Mattice Hill. We say 'available' because, as the author notes, many of the bores being made by chisel there were no 'cores' of the softer beds. Detailed reports are promised later by Mr. Arber and Mr. H. Bolton.

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